308 - - - Q200409240005

Scientific Notebook No. 273: Unsaturated Flow Modeling at Yucca Mountain Isothermal Shallow Infiltration and Deep Percolation (06/04/1998 through 08/31/2004)

#273

21
150

R

Randy Fedors - USFIC KTI
Unsaturated Flow Modeling

Contents | Page

Title: Unsaturated flow modeling at Yucca Mtn; Isothermal Shallow Infiltration & Deep Percolation

People: Randy Fedors
Stu Stothoff
Dani Or
David Groeneveld
David Woolhiser
Oliver Chadwick

Project:

Computational work for the USFIC KTI in the area of unsaturated flow modeling is the primary component of this notebook. Primarily, deep percolation modeling will be addressed although shallow infiltration work currently underway with Stu Stothoff, Dani Or, David Groeneveld, David Woolhiser, and Oliver Chadwick (all consultants to CNWRA) will also be included.

Contents

Page

Pulse of water from Solitario Canyon

As part of the deep percolation aspect of unsaturated flow at Yucca Mountain, the influx of water from the west side of Yucca Mtn will be modeled. There are two aspects that could be addressed (i) infiltration onto west flank and direct inflow into PTn & TSw and then lateral movement combined with vertical movement towards the repository or perched water zones; and (ii) link Woolhiser's modeling in Solitario Canyon to unsaturated flow model by just taking one of his large runoff events (8-10 yr event) and model the pulse into the sediments (alluvium) to first see how the pulse moves through the alluvium, then model the pulse into the bedrock along the TSw to see how a pulse would move into the repository or perched water zone (movement along cooling joints & tectonic fractures rather than along major fault zones.

Models (codes) currently under consideration are HYDRUS-2D from the U.S. Salinity Lab (U.S. Dept. of Agriculture, Agricultural Research Service) and the FEHMN code from Los Alamos National Laboratory. HYDRUS-2D is a finite element and, as ordered, has an interface & gridder for the Windows environment. HYDRUS-2D is a single continua model, FEHMN is a 3dimensional, dual-continua, finite element model and I am trying to get an interface and gridder called Geomesh/LaGrit (also put out by the EES-5 group at Los Alamos National Lab. HYDRUS-2D would be used first, as a simplified system, for exploratory simulations. The parameter/data needed for the alluvium and for the bedrock needs to be assembled. A starting point for the tuffs would be either the LANL grids & input files or an extraction of the LBNL UZ model parameters. For the TSw both models use uniform parms for the hydrostratigraphic units. We may explore the use of stochastically-generated parameters with each unit.

HYDRUS-2D ordered from
IGWMC
Colorado School of Mines
1500 Illinois St.
Golden CO 80401-1887
Phone (303) 273-3103
igwmc@mines.edu

FEHMN is much more difficult to obtain
(1) We have to have someone at SwRI sign a software user form for LANL, then the source code can be iftp'd from their site
(2) Contact is Lynn Trease, EES-5
Fax: (505) 665-3687
Office: (505) 667-0140
llt@vega.lanl.gov
(3) I was given the following ftp account & password
% iftp ees-5.lanl.gov
Name: fehm
Passwd: fehm.95Ø221

I had obtained a fortran-77 version last fall but had difficulties compiling it. ⇒ "cd ./fehm/objects/" & then "make"
(1) compile error at c_close.c
This error was tracked to our system using lower case "cc" for the compatibility compiler instead of the standard c-language compiler. Our system uses upper case "CC" for the c-compiler. I had to edit the makefile in ./fehm/objects/
(2) still had compile errors at c_close.h apparently when "fd" variable is addressed by reference to include file "fcntl.h. It appeared that the paths to the system include files was not set up, so once I found fcntl.h in /usr/include/, I just copied it to the current directory for the compile ⇒ ./fehm/objects/

I emailed Lynn Trease who responded in 3 or 4 days once I used by old school email account (I have been having trouble with email not getting to my ccmail account).
Lynn Trease's instructions were:
(1) use the fortran90 version since the other one is no longer supported; use the iftp account to get
fehm90-source.tar
then untar it and
make xinclude
make xfehm
(2) The makefile was in ./fehm/newptrk although Bruce Robinson certainly made my life difficult by tar'ing the file starting from the root directory (/home/robinson/*)
Ray Kokura had to disable automount on bren (this only took 2 hours of his time)
The next problem is that we no longer have an active license for fortran90 for the SUNs (nor the SGIs). This has taken Ray a couple days to sort out, and we still don't know if we have an F90 license for UNIX
/solapps/SUNWspro-new/
/solapps/craysoft/
both had license problems for F90

6/12/98 Since the CNWRA does not have a fortran 90 license for SUNs yet, Bruce Robinson (LANL) graciously sent an executable for SUN Ultra running Solaris (5.5.1)

6/12/98 Getting GEOMESH/LaGriT
get software agreement & LaGriT requirements from
http://www.ees.lanl.gov/EES5/geomesh
(1) Chris Freitas signed the Software USER agreement
(2) Get pgp encrypter (as described by LaGriT requirements)
http://web.mit.edu/network/pgp

 6/12/98 RF

3. Third item to send Carl Gable is the machine for a node-locked executable

% uname -a

SunOS bren 5.5.1 Generic_103640-12 sun4m sparc SUNW,SPARCstation-10

% hostid

7231bb30

To make pgp

unzip & untar the pgp file from mit.edu

RF 8/25/00 ~~cd to~~ ./ untar rsaref.tar & untar pgp262si.tar

cd ./rsaref/install/unix

make CC=CC

use CC (upper case) instead of lower case cc because CNWRA decided to use the latter for the compatibility compiler instead of the c-language

also tried PROTOTYPES=0

neither make worked

due to error in 'Context not defined in ../../source/desc.c

I will try gnu cc compiler as recommended since our C-compiler always seems to cause me problems (non-standard?)

ftp://ftp.ms.uky.edu/pub3/gnu (gotten from http://www.gnu.org/)

So now I will try to compile the gcc program so that I will be able to use the gcc-compiler for pgp compiling

gcc-2.7.2.3.tar.gz dated Aug97 (I avoided latest version 3/98)

gunzip *.tar.gz

tar xvf *.tar

./configure --prefix=/export2/rfedors/GCC/bin → use instead of /usr/local/bin

See INSTALL & README for instructions

6/12/98 RF

RF 8/31/04 caps

According to Simon & Goodluck, the CC is the C++ compiler and the cc is the c-compiler at CNWRA

Not being a c-language person, I am now left with the possibility that bren or my account are not set up to use the compilers

6/15/98 Ray Kotara is in process of adding gcc compiler for everyone to use.

6/23/98 Copied "gcc" compiler from Simon's machine (shsiung), keeping the same directory structure onto bren and then changed paths in .cshrc.local file adding

set path = ($path ~/bin/GCC/bin ~/bin/GCC/lib/gcc-lib/sparc-sun-solaris2.5.1/2.7.2.2/)

I had to add the last path due to compiler ~~error~~ not finding "cpp"

Now back to compiling

tar xvf pgp262s.tar → creates 5 files

tar xvf pgp262si.tar

tar xvf rsaref.tar

cd ./rsaref/install/unix

make (this builds rsaref software) no errors this time, ranlib ok

cd ../../../src

make sunspc (did not work, apparently wrong target machine type)

instead use:

make sun4sunos5gcc

Zeolite Data

Obtained Stratamodel's interpolation of zeolite abundances report in Chipera reports noted below. The ftp site is
ees5-ftp.lanl.gov
cd pub/Karen/ymp
bin
get 3Dmin.asc (1-17-97) (x,y,z, coordinates & all x-ray results)
get 3Dminzeo.asc (2-4-97) (just zeolites)
get 3Dmin.new (2-4-97) (apparently an update of 3Dmin.asc)
date stamps are for dates on Los Alamos ftp site

3Dminzeo.asc x, y, z, % zeolites
units are feet, Nevada State coordinates

3Dmin.new x, y, z, smectite, zeolite, tridymite, cristo/opal CT, glass

each of these has 69406 records, including the column header at the top of the files

currently stored in ~/zeolites/

FTP reference found in:

Chipera, S.J., K. Carter-Krogh, D.T. Vaniman, D.L. Bish, and J.W. Carey. 1997. Preliminary Three-Dimensional Mineralogic Model of Yucca Mountain, Nevada. YMP Milestone SP321AM4, EES-13-01-97-1361, Los Alamos National Laboratory.

Chipera, S.J., D.T. Vaniman, D.L. Bish, and J.W. Carey. 1997. Mineralogic Variation in Drill Holes USW NRG-6, NRG-7, NRG-7/7a, SD-7, SD-9, SD-12, and UZ#14. New Data from 1996-1997 Analyses. YMP Milestone SP321BM4, Los Alamos National Laboratory.

These documents contain appendices with XRD data for wells

1st Chipera et al. report:

UE-25a#1	USW G1	USW H-3	USW SD-7
UE-25b#1	USW G2	USW H-4	USW SD-9
UE25p#1	USW G-3/GU-3	USW H-5	USW SD-12
UE-25 UZ#16	USW G-4	USW H-6	USW WT-1
~~continued next page~~ PF 8/25/00		~~UZN 32~~ UZ#16	USW WT-2

2nd Chipera et al. report:
USW NRG-6, NRG-7/7a, SD-7, SD-9, SD-12, UZ#14, USW H-3, USW H-5 } portions rechecked against earlier report

The zeolite data will initially be used for comments in IRSR. A comparison will be made between the following
(1) actual x-ray data (3817 points)
(2) interpolated values from LANL running STRATAMODEL
(3) LBNL application to hydrogeologic model used as a grid for UZ flow

6/22/98 PF
Received updated version of 1997 Chipera et al 3D Mineralogic Model →

Carey, J.W., S.J. Chipera, D.T. Vaniman, D.L. Bish, H.S. Viswanathan, and K. Carter-Krogh
Three-Dimensional Mineralogic Model of Yucca Mountain, Nevada
Los Alamos National Lab Milestone SP344BM4
Revision 1, 9/24/97

Data entry of zeolite weight percent based on Carey et al. revision. Cross-checked against Chipera et al (1997) Milestone SP321BM4 which has the zeolites broken down into different types (it is primarily a zeolite mineral variation report)

zeolites → clinoptilolite, heulandite, mordenite, chabazite, erionite, stellerite

PF 8/25/00

 6/25/98 PF

Goal ⇒ Create figures of zeolite wt % mapped onto Geologic Framework Model (GFM 3.0) 3.0

Using the ONYX SGI running EarthVision 4.x, GFM3.0 from DOE, and zeolite data from LAN2 interpolation/prediction from STRATMODEL (see page 6), map zeolite data to the non-welded units in order to analyze the distribution with respect to Berkeley contention of a zeolite hole in center of repository and small zeolite thicknesses to south.

GFM30 ⇒ /pscr2/models/GFM3/ver3.001/Horizons
./Isochores

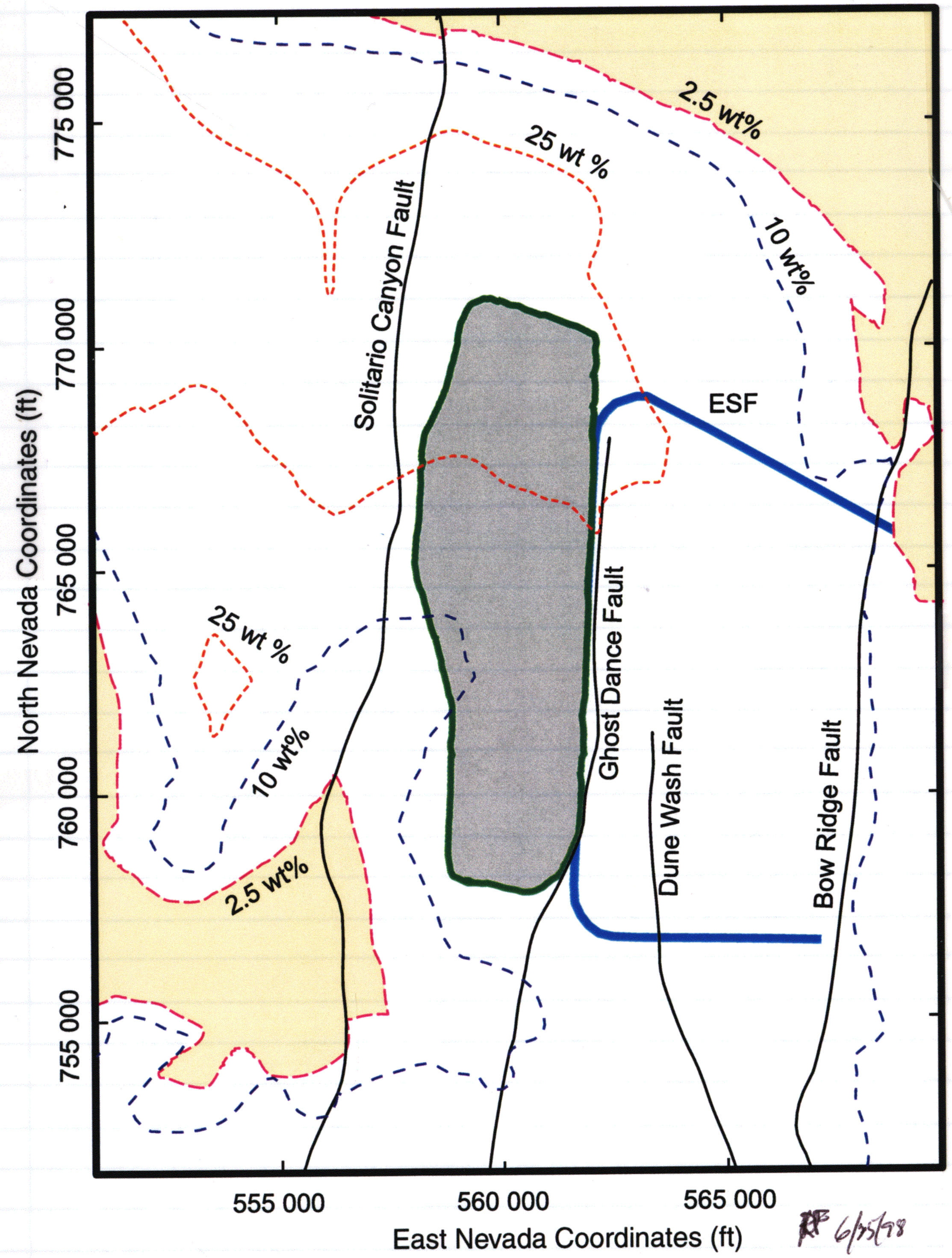
EarthVision Methodology
Use Geologic Structure Builder
↳ define range
↳ select sequence (delete units not interested in maps zeolite; i.e. TCw, TSw, Tram etc.)
↳ Define properties – conformal gridding, vertical influence factor used to ~~influence~~ (PF 6/25/98) enhance lateral continuity
↳ Calculate
↳ Struc Model
↳ zone surfaces
↳ zone blocks
↳ property model (all zeol property zeolite.grd/.pdat)

Had to delete many lithologic units & cut down on the range because EarthVision was taking too long to do the mapping (1 week & running). So I focused on mapping the zeol to the Tpbt1/Calico contact (other units were tried but EarthVision would crash after extensive computing; apparently it needed continuity of units across domain). Robert Clayton has asked SGI to fix this general problem of mapping property sets to faces files of lithologies.

PF 6/25/98

In my home directory on SGI ⇒ ./zeol/Tpbt1-Cal/*
zeolite.pdat
tpbt1_cal.seq

2D map of zeolite distribution along contact of Tpbt1 and Calico. Image was manipulated in Showcase to bring out the 2.5, 10, and 25% contours. 6/25/98 PF

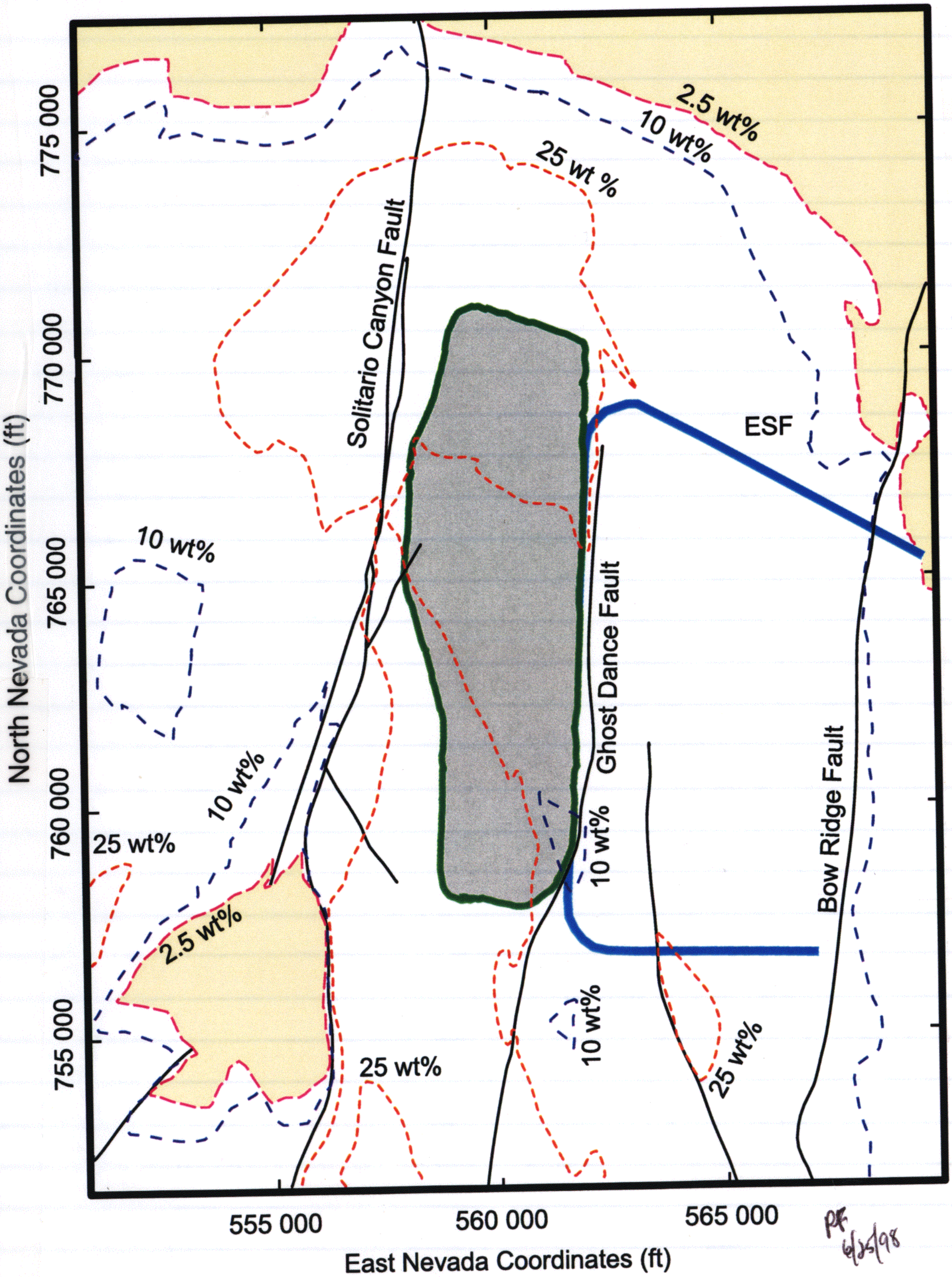


PF 6/25/98

Figure 4. Zeolite weight percent contours over the same area as Figure 3 using interpolated data referenced in Carey, et al. (1997) in the lower portion of the Calico Hills Formation.

 6/25/98 RF

2D map of zeolite distribution for a horizontal plane at elevation of 2709 ft (near Tpbt1 / Calico contact). Image was edited in Showcase (SGI program) to highlight 2.5, 10, and 25 wt.% zeolite contours.



RF 6/25/98

Figure 5. Zeolite weight percent contours over the same area as Figure 3 using the interpolated data referenced in Carey, et al. (1997) at the 2709 foot elevation (above mean sea level).

RF
6/25/98

Variably Saturated Flow Paths Below the Repository & Sorption of Radionuclides by Zeolites

Flow and transport below the repository will be through or around the vitric and zeolitic horizons of the basal Topopah Springs Tuff, the Calico Hills Formation, and the upper Prow Pass Tuff. The nature of the flow paths are highly uncertain due to sparse data on the lateral and vertical variations in zeolitic alteration. The current conceptual model is that flow will bypass the zeolite horizons and will flow through the matrix of the non-welded vitric horizons and through fracture systems. Flow through the vitric horizons may be uniform or may be non-uniform as fingers of flow in high conductivity zones in this heterogeneous unit. The nature of the thinly intercalated layers in the vitric and zeolitic horizons may alter the conceptualization of flow. The degree to which radionuclides contact the zeolite minerals is dependent on the flow paths. In this conceptualization of flow, the predominant contact of radionuclides with zeolites will occur in slighltly altered vitric horizons. Minimal contact will occur along fractures. The definition of "slightly" is on the order of 5 wt. % zeolite but this is an unsupported approximation and must be studied further. Currently, DOE uses 10% as a delineation between non-altered, vitric and zeolitically altered for modifying hydraulic parameters in the LBNL UZ flow model. An additional area requiring further work is the relationship of sorption coefficients with weight percent zeolite.

Lateral continuity of the zeolites is expected along the stratigraphic nonwelded, vitric units below the repository. Based on x-ray diffraction data, the zeolite weight percent ranges from 0 to the mid-80s. A large portion of the zeolites are postulated to have formed as alteration from warm fluids under saturated conditions; implying both a thermal event and perched or water table conditions. A small amount of the zeolites may be primary in origin (at G-3 for example). The zeolites have been identified as clinoptilolite, mordenite, heulandite, chabazite, erionite, and stellerite.

Although lateral continuity is expected due to the postulated origin for the alteration, there is a complex interstratification of zeolite alteration and glass with highly variable profiles between cores and thinly intercalated layering within a cores. This gives rise to the notion that the vitric and zeolitic horizons are broadly overlapping. Faulting that post-dates the zeolite alteration lends itself to the complexity.

LANL has 1503 x-ray measurements at 21 boreholes, 18 of which cross the vitric and zeolitic horizons near the Calico Hills Formation. The units of interest, based on the nomenclature of Buesch et al. (1995), are:

- Tpvpt2
- Tpvpt1
- Tpbt1
- Tac
- Tacbt
- Tcp (which in the GFM3.0 is subdivided into Prowuv, Prowuc, Prowmd, Prowlc, Prowlv)
- Tcpbt

Of primary interest are the vitric units above the current water table. Generally speaking, the water table intersects the Tac unit (in the Calico Hills Formation) in the northwest portion of the repository vicinity and intersects the Tcp unit (in the Prow Pass Tuff) in the south and southeast.

./rfedors/USFIC/vitric.wpd

Introductory writeup for zeolitic/vitric thicknesses

RF 6/25/98

11

PF 6/25/98

Wells for which there is x-ray data on zeolites

UE-25a#1	**G-1**	**SD-7**
UE-25b#1	G-2	**SD-9**
UE-25p#1	G-3/GU-3	**SD-12**
UZ#14	**G-4**	**WT-1**
UZ#16	**H-3**	**WT-2**
	H-4	NRG7/7a
	H-5	
	H-6	

The wells in bold type are in near vicinity to the repository footprint, or immediately down-gradient if lateral flow is incorporated. Mineralogic logs or in other logs such as for resistivity may yield useful information, however, the extent and availability is not known. There may other data measured on cores or in the boreholes that could help delineate the mineralogic section. DOE/M&O contacts for the type of information availability include Robert Clayton (M&O), Chris Rautman (SNL), Bill Carey (LANL), or Steven Chipera (LANL). Pertinent documents for the mineralogic modeling are Loeven (1993), Moyer and Geslin (1995), Carey et al. (1997), Chipera et al. (1997), and Bussod et al. (1997). Pertinent hydrologic modeling reports that address the incorporation of the mineralogic data into unsaturated flow and transport models are Bodvarsson et al. (1997) and Robinson et al. (1997).

An additional concern is that there is a possibility that the sampling strategy for the zeolites was a biased scheme (purposely focusing on the horizons that appeared to be altered). Thus, correlating the mineralogic logging with the zeolite data will probably be necessary to separate the vitric from the altered aggregate thicknesses.

Other wells in the vicinity of the repository may yield information on the aggregate thickness of the vitric, non-welded units in the unsaturated zone below the repository even if there were no associated x-ray data.

Introductory writeup for zeolitic/vitric thicknesses

PF 6/25/98

11

Summary

The first step is to develop a detailed characterization of the stratigraphic units described above and correlation with the zeolite data. The PA group needs an aggregate thickness of the vitric horizons below each repository subarea. The next step will be to refine the conceptual model of flow and to apportion the flow into matrix and fracture components. The last step will be to identify appropriate sorption coefficient values for the vitric horizons, which include zones with a small amount of zeolites. We already have the zeolite weight percent data, both the actual data from core samples and the interpolated data from Los Alamos National Laboratory.

References

Bodvarsson, G.S., T.M. Bandurraga, and Y.S Wu. 1997. The Site-Scale Unsaturated Zone

Model of Yucca Mountain, Nevada, for the Viability Assessment; LBNL-40376, UC-814, Lawrence Berkeley National Laboratory, Berkeley, CA.

Bish, D.L., J.W. Carey, B.A. Carlos, S.J. Chipera, G.D. Guthrie, Jr., S.S. Levy, D.T. Vaniman, and G. WoldeGabriel. 1995? Summary and Synthesis Report on Mineralogy and Petrology Studies for the Yucca Mountain Site Characterization Project, Volumes I, II, III; Milestone 3665, Los Alamos National Laboratory, Los Alamos. Copy from Bradbury's office, not dated; check with authors for possible update.

Bussod, G.Y., B.A. Robinson, D.T. Vaniman, D.E. Broxton, and H.S Viswanathan. 1997. UZ Transport Test Plan Rev. 1 FY98-02, Demonstration of the Applicability of Laboratory Data to Repository Transport Calculations: Field-Scale Experiments to Study Radionuclide Transport at Yucca Mountain; Letter Report, Milestone SP341SM4, Los Alamos, NM: Los Alamos National Laboratory.

Carey, J.W., S.J. Chipera, D.T. Vaniman, D.L. Bish, H.S. Viswanathan, and K. Carter-Krogh. 1997. Three-Dimensional Mineralogic Model of Yucca Mountain, Nevada, Rev.1; Yucca Mountain Project Milestone No. SP344BM4 draft Sept. 1997, Los Alamos National Laboratory, Los Alamos, NM.

Chipera, S.J., D.T. Vaniman, D.L. Bish, J.W. Carey. 1997. Mineralogic Variation in Drill Holes USW NRG-6, NRG-7/7a, SD-7, SD-9, SD-12, and UZ#14: New Data from 1996-1997 Analyses; Yucca Mountain Project Milestone No. SP321BM4, Los Alamos National Laboratory, Los Alamos, NM.

Loeven, C. 1993. A Summary and Discussion of Hydrologic Data from the Calico Hills Nonwelded Hydrogeologic Unit at Yucca Mountain, Nevada; LANL Report LA-12376-MS, UC-814, Los Alamos National Laboratory, Los Alamos, NM.

Moyer, T.C. and J.K. Geslin. 1995. Lithostratigraphy of the Calico Hills Formation and Prow Pass Tuff (Crater Flat Group) at Yucca Mountain, Nevada; U.S. Geological Survey Open-File Report 94-460, Denver, Colorado.

RF 6/25/98

Introductory writeup for zeolitic/vitric thicknesses

RF 6/25/98

11

Borehole	Geology Rpt	Obtained	Geohydrology	Obtained
UE-25a#1	Spengler 1979	✓		
UE-25b#1			Lobmeyer 1983	✓
UE-25p#1	Carr 1986	✓	Craig 1984/Lahood 1984	✓
UZ#14				
UZ#16				
G-1				
G-2	Maldonado 1983	✓		
G-3/GU-3	Scott 1984			
G-4	Spengler 1984	✓	Lobmeyer 1986	✓
H-3			Thordarson 1985	✓
H-4			Whitfield 1985/Erickson 1985	✓
H-5			Bentley 1983	✓
H-6			Craig 1991	✓
SD-7	Rautman 1996	✓	O'Brien 1997	✓
SD-9	Moyer 1994			
SD-12	Rautman 1996	✓		
WT-1	Spengler 1993			
WT-2	Spengler 1993			
NRG7/7A (into CHn but not to water table)				

Boreholes in bold are near the repository footprint

GEOLOGY

✓Carr, M.D., S.J. Waddell, G.S. Vick, J.M, Stock, S.A. Monsen, A.G. Harris, B.W. Cork, and F.M. Byers. 1986. Geology of drill hole UE25p#1: A test hole to pre-Tertiary rocks near Yucca Mountain, southern Nevada: U.S. Geological Survey Open-File Report 86-175. 87 p. **GS930283117461.002**

Diehl, S.F., and M.P. Chornack. 1990. Stratigraphic correlation and petrography of the bedded tuffs, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 89-3. 152 p. **GS900908314211.012**

Geslin, J., T. Moyer, and D.C. Buesch. 1994. Summary of Lithologic Logging of New and Existing Boreholes at Yucca Mountain, Nevada. August 1993 to February 1994: U.S. Geological Survey Open File Report 94-342. 68 p. **GS940308314211.009**

Moyer, T.C. and G. Mongano. 1994. Graphical Lithologic Log of Borehole USW SD-9 From the Base of the Paintbruch Group to Total Depth. GS941108314211.052

✓Maldonado, F., and S.L. Koether. 1983. Stratigraphy, structure, and some petrographic features of Tertiary volcanic rocks at the USW G-2 drill hole, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 83-732. 83 p. **GS930208314211.008**

✓ Rautman, R.A., and D.A. Engstrom. 1996. Geology of the USW SD-7 Drill Hole, Yucca Mountain, Nevada, SAND96-1474, Albuquerque, NM: Sandia National Laboratories.

✓ Rautman, R.A., and D.A. Engstrom. 1996. Geology of the USW SD-12 Drill Hole, Yucca Mountain, Nevada, SAND96-1368, Albuquerque, NM: Sandia National Laboratories.

Scott, R.B. and M. Castellanos. 1984. Stratigraphic and Structural Relations of Volcanic Rocks in Drill Holes USW GU-3 and USW G-3, Yucca Mountain, Nye County, Nevada, Open-File Report 84-891, U.S. Geological Survey.

Spengler, R.W. 1993. Preliminary Lithologic Well Reports; USW WT-1, 2 7, 10 and UE-25 WT-3, 16, 17, 18. GS930208312411.004

✓Spengler, R.W., and M.P. Chornack. 1984. Stratigraphic and structural characteristics of volcanic rocks in core hole USW G-4, Yucca Mountain, Nye County, Nevada, with a section on Geophysical logs by D.C. Muller and J.E. Kibler: U.S. Geological Survey Open-File Report 84-789. 77 p. **GS920908314211.003**

✓Spengler, R.W., D.C. Muller, and R.B. Livermore. 1979. Preliminary report on the geology and geophysics of drill hole UE25a-1, Yucca Mountain, Nevada Test Site: U.S. Geological Survey Open-File Report 79-1244. 43 p. **GS920908314211.004**

GEOHYDROLOGY

Brocher, T.M., P.E. Hart, W.C. Hunter, and V.E. Langeheim. 1996. Hybrid-source seismic reflection profiling across Yucca Mountain, Nevada: Regional lines 2 and 3: U.S. Geological Survey Open-File Report OFR-96-28. 94 p. **GS960108314211.002**

✓Bentley, C.B., J.H. Robison, and R.W. Spengler. 1983. Geohydrologic data for test well USW H-5, Yucca Mountain area, Nye County, Nevada: USGS Open-File Report 83-853. 34 p. **GS910908312132.002**

✓Craig, R.W., R.L. Reed, and R.W. Spengler. 1983. Geohydrologic data for well USW H-6, Yucca Mountain area, Nye County, Nevada, Open-File Report 83-856, Denver, CO: U.S Geological Survey, 39 p. **GS910908312132.001**

✓Craig, R.W. and R.L. Reed. 1991. Geohydrology of Rocks Penetrated by Test Well USW H-6, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 89-4025. 40 p.

✓Craig, R.W. and J.H. Robison. 1984. Geohydrology of Rocks Penetrated by Test Well USW UE-25p#1, Yucca Mountain, Nye County, Nevada, U.S. Geological Survey Open-File Report 84-4248, Denver, CO: U.S. Geological Survey, 40 p.

✓Erickson, J.R. and R.K. Waddell. 1985. Identification and Characterization of Hydrologic Properties of Fractured Tuff Using Hydraulic and Tracer Tests – Test Well USW H-4, Yucca Mountain, Nye County, Nevada, Water-Resources Investigations Report 85-4066, Denver, CO: U.S. Geological Survey.

✓Geldon, A.L. 1993. Preliminary Hydrogeologic Assessment of Boreholes UE-25c#1, UE-25c #2, and UE-25c#3, Yucca Mountain, Nye County, Nevada, Water-Resources Investigations Report 92-4016, Denver, CO: U.S. Geological Survey.

✓Lahood, R.G., D.H. Lobmeyer, and M.S. Whitfield. 1984. Geohydrology of Rocks Penetrated by Test Well USW UE-25p#1, Yucca Mountain, Nye County, Nevada, Water-Resources Investigations Report 84-4253, Denver, CO: U.S. Geological Survey.

✓Lobmeyer, D.H. 1986. Geohydrology of Rocks Penetrated by Test Well USW G-4, Yucca Mountain, Nye County, Nevada Water-Resources Investigations Report 86-4015, Denver, CO: U.S. Geological Survey.

✓Lobmeyer, D.H., M.S. Whitfield, Jr., R.R. Lahoud, and L. Bruckheimer. 1983. Geohydrologic Data for Test Well UE-25b#1H, Nevada Test Site, Nevada: U.S. Geological Survey Open-File Report 83-855. 52 p. **GS930408312313.004**

✓O'Brien, G.M. 1997. Analysis of Aquifer Tests Conducted in Boreholes USW WT-10, UE-25 WT#12, and USW SD-7, 1995-96, Yucca Mountain, Nevada, Water-Resources Investigations Report 96-4293, Denver, CO: U.S. Geological Survey.

✓Thordarson, W.,F.E. Rush, R.W. Spengler, and S.J. Waddell. 1984. Geohydrology and drill-hole data for test well USW H-3, Yucca Mountain, Nye County, Nevada: U.S. Geological Survey Open-File Report 84-149. 28 p. **GS900908312312.001**

✓Thordarson, W.,F.E. Rush, R.W., and S.J. Waddell. 1985. Geohydrology of Test Well USW H-3, Yucca Mountain, Nye County, Nevada, Water-Resources Investigations Report 84-4272, Lakewood, CO: U.S. Geological Survey.

✓Whitfield, M.S., Jr., E.P. Eshom, W. Thordarson, and D.H. Shaefer. 1985. Geohydrology of rocks penetrated by test will USW H-4, Yucca Mountain, Nye County, Nevada, Water-Resources Investigations Report 85-4030. Denver, CO: U.S. Geological Survey. 33 p. **GS920408312314.008**

Whitfield, M.S., Jr., W. Thordarson, and E.P. Eshom. 1984. Geohydrologic and drill hole data for test well USW H-4, Yucca Mountain, Nye county, Nevada: U.S. Geological Survey Open-File Report 84-49, 39 p. **GS900908312312.002**

Initial Cut at vitric thicknesses below subareas

From geology and hydrology reports on each well (as available) delineate zeolitic thickness, non-welded/non-altered thickness, and welded thickness (not including TSw, only for Prow Pass & Bullfrog as above water table). Then cross-check against Carey and Vaniman, and Chipera data (see references) noting that they use different unit stratigraphy. For the wells without mineralogic reports, use the x-ray diffraction tabulations (assume non-welded/non-altered if zeolite <10%) → for now.

Note that the word vitric is not used. Based on flow properties, the importance is on non-welded versus zeolitic. If there are welded vitric horizons, these will not support significant matrix flow. Both the altered and the non-welded/non-altered could also have fracture or finger flow — this will be ignored for now. It can also be noted that if the horizon is non-welded/non-altered, it is probably vitric (but the reverse is not true).

Well locations in Nevada State Plane				1996 or Loeven (1993)
Easting(ft)	Northing(ft)	Elev(ft)	Well Name	Potentiometric Surface (m)
566350	764900	3932.8	UE-25a#1	728.8 CHn
571485	765171	3655.0	UE-25p#1	
564888	760535	4000.6	UZ#16	
560282	771506	4429.1	UZ#14	
561000	770477	4348.6	G-1	754.2 Prow Pass
560513	778803	5098.0	G-2	1019.4
558497	752650	4856.9	G-3	730.2 Bullfrog
563036	765764	4166.9	G-4	730.0 Prow Pass
558446	756546	4866.1	H-3	732.4 Bullfrog
563904	761643	4097.0	H-4	729.8 Prow Pass
558897	766624	4851.0	H-5	774.7 Bullfrog
554166	763260	4270.9	H-6	776.3
561240	758950	4470.0	SD-7	729.4 Prow Pass
561591	768058	4272.5	SD-9	730.9 Prow Pass
561606	761957	4343.0	SD-12	729.9 Prow Pass
563739	753941	3942.1	WT-1	730.3
561924	760661	4269.9	WT-2	730.6 Prow Pass

RF 10/19/98

SD-7

nw = non-welded ; nalt = non-altered

elev 4472 ft
x (east) 561240.3'
y (north) 758949.9'
water depth 2079' (page 8 of ref.)

Thicknesses (ft) ← 1295 ft depth

TSw (vitric nw)	69	
TSw (bedded)	41	
Tac_3	88.3	
Tac_2	30.5	zeol 1505
Tac_1	43.4	} 150
Tac (bedded)	43.1	
Tac (basal sand)	15.9	
Tcp_4	28.8	1655' depth
Tcp_3 (mod welded)	182.8	
Tcp_2	40.2	zeol 1865' } 214; water @ 2079'
Tcp_1	289.0	← contact @ 2167' depth
Tcp (bedded)	12.7	

Tptpvl	∅	1357' depth
Tpbt1	24 ft	1381' depth
		1493 zeol
Tacbt		1567.2; zeol 149
		1617'
Tcpunw		1642' contact
Tcpuw		1855'
Tcplnw		zeol 224
		2167
Tpbt		

welded (TSw) ⇒ 336 ft → RF 10/20/98 ← welded (TSw) ⇒ 398
zeol ⇒ 364 ft — zeol → 373 ft
nw/nalt ⇒ 210 ft — nw/nalt → 136 ft
welded (prow) ⇒ 210 ft — welded (prow) ⇒ 213 ft
total ~~784~~ ft 1120 — RF 10/20/98 — ~~722~~ ft RF 8/25/00 1120

3513 − [4472 − 1295] = 336

Rautman & Engstrom
SAND96-1474

Carey et al (1997)
30 Sept 1997, Rev 1
SP344BM4

for stratigraphic relations see page 20, Table 1

SD-12

elev (ft) 4342.8
x (east) (ft) 561,605.6
y (north) (ft) 761,956.6
water depth (ft) 1948 (from log, static assumption)

Thicknesses (ft) ← 1339' depth

TSw (vitric nw)	72.3	zeol @ 1381'
TSw (bedded)	—	
Tac_4	63.7	
Tac_3	79.0	258'
Tac_2	46.6	
Tac_1	11.0	
Tac (bedded)	29.7	zeol to 1639'; contact at 1641'
Tac (basal sand)	7.1	
		contact at 1648
Tcp_4	8.2	zeol 1650 to 1657'
Tcp_3	215.1	1830' } 118
Tcp_2	74.9	zeol 1947' contact
Tcp_1	186.0	

	1337.5 ft
Tptpvl	1408
Tpbt1	1411.5 } zeol 410.8
Tac	1520 zeol
	1589.4
Tacbt	zeol 1648.4
	zeol
Tcpunw	1668
Tcpuw	1867
Tcplnw	zeol 2136.4

3513 − [4342.8 − 1339] = 509

welded (TSw) ⇒ 509 ft → RF (10/20/98) ← 508 ft
zeol ⇒ 383 ft — 229 ft
nw/nalt ⇒ 53 ft — 182.5 ft
welded (prow) ⇒ 173 ft — 199 ft
~~609~~ 1118 ft — RF 10/20/98 — total ~~610.5~~ ft 1118 ft

Rautman & Engstrom
SAND96-1368

Carey et al 1997
30 Sept 97, Rev 1
SP344BM4

SD-9

elev (ft) 4275
x(east) ft 561,818.0
y(north) ft 767,988.5
water depth (ft) 1877 (page 7)

Thicknesses (ft) —1445' depth

TSw (vitric nw)
TSw (bedded)
Tac3
Tac2
Tac1 zeol
Tac (bedded)
Tac (basal sand)

Tcp4
Tcp3 — water @ 1877'
Tcp2 ← contact at 2015.8'

Tptpvl —1425.7 (1434) —1464.1
Tpbt1 —1479.9
Tac —1764.4
Tacbt —1820.7 (zeol.)
Tcpunw —1875
Tcpuw ← water table 1877

3513 − [4275 − 1445] = 683'
drift, ground surface, top of non-welded

RF 10/20/98

welded (TSw) ⇒	683 ft		welded (TSw) −	663.7
Zeol ⇒	432 ft		zeol	441 ft
nw/nalt ⇒	ϕ		nw/nalt	8.3 ft
welded (prow) ⇒	ϕ		welded (prow)	~~ϕ~~ ft
	~~432~~ ft		total	~~451.3~~ ft
	1115 ft RF 10/20/98			1115 ft RF 10/20/98

Engstrom & Rautman
SAND 96-2030

Carey et al 1997
30 Sept 1997, Rev 1
SP344BM4

NRG-7/7A

Not drilled down to water table, only 15 feet into Calico Hills unit.

Tptpvl —1474.6 —1493.0
Tpbt1 zeol —1498.0
Tac — bottom 1513.4

10/20/98 Reported Zeolitic Thicknesses

Vaniman et al. 1984 p.57, LA-9707-MS (LANL)
zeolites between repository and static water level

G-1	142 m	(466 ft)
UE-25a#1/UE-25b#1	69 m	(226 ft)
G-4	126 m	(413 ft)
H-4	108 m	(354 ft)
H-5	44 m	(144 ft)
H-3	87 m	(285 ft)
G-3/GU-3	60 m	(197 ft)

RF 10/20/98

Also need the thickness of welded units for all wells from below repository to top of first non-welded units at base of TSw. As a first approximation, I will use the average from the subareas (excluding subarea 1) of the thicknesses from the TPA base case* added to a water potentiometric surface of 730 meters to get a vertical position of the drifts

Carey et al 1997
30 Sept 97, Rev 1
SP344BM4

average thickness for subareas 2-7 ⇒ 340.7 m
water table ⇒ 730 m elev
drifts ⇒ 340.7 + 730 = 1071 m elev
= 3513 ft elev.

* Total-System Performance Assessment (TPA) Version 3.2 code: Module Descriptions and User's Guide, Sept 1998, CNWRA Mohanty & McCartin
see page 4-76

 10/19/98 RF

H-4

elev ft	4097.0
x(east) ft	563911
y(north) ft	761644
water depth (ft)	1702.6

729.8 m water elev

Thicknesses (ft)

	— 1230
Tptpvl	— 1312.0
Tac	1340 (zeol) — 1575
Tacbt	— 1627.0
Tcpunw	— 1653.0
Tcpuw	— 1850 (water table — 1702.6)
Tcplnw	(zeol) — 2263

RF 10/5/01

3513 − [4097 − 1230] =

welded (TSw) ⇒ 646 ft
zeol ⇒ ~~287~~ ft
nw/nwelt ⇒ 185.6 ft
welded (Prow) ⇒ φ

1118.6 ft

Carey et al 1997
30 Sept 97, Rev 1
SP344BM

10/19/98 RF

H-5

water table @ 774.7 meters elev.

elev ft	4850.7
x(east) ft	558,943
y(north) ft	766,643
water depth, ft	2309.0

Thicknesses (ft)

— 1654.8' depth

Tsw (vitric nw)	44.3
Tsw (bedded)	11.1
Tac	169.9
	— 1880 ft depth
Tac (bedded) zeol	65.0
Tcp (nw vitric)	24.9
Tcp (partial weld)	154.9
Tcp zeol	115.1
Tcp (bedded) zeol	230 — contact @ 2263'

← water table 2309' depth

Tptpvl	φ — 1699.2
Tpbt1	— 1710
Tac	— 1880
Tacbt	(zeol) — 1945
Tcpunw	— 1965
Tcpuw	— 2175
Tcplnw	(zeol) — 2240.3
Tcbt3	— 2263.2
Tcbunw	(zeol) — 2280.0
Tcbt2	— 2713.1

Bullfrog

Thicknesses

3513 − [4850.7 − 1654.8] = 317.1

welded (TSw) ⇒	317.1 ft	→ RF 10/20/98 →	361.5
zeol ⇒	203.1 ft	→	167 ft
nw/nwelt ⇒	250.2 ft	→	180.8 ft
welded (prow) (Bullfrog) ⇒	200.9 ft (Prow → 154.9', Bullfrog → 46')	→	261.9 ft
total	~~654.2~~ ft		
	971.3 ft	RF 10/20/98	

Bentley et al. 1983
USGS-OFR-83-853

Carey et al. 1997
30 Sept 97, Rev 1
SP344BM

UE25a#1

elev ft 3932.8
X(east) ft 566,350
y (north) ft 764,900
water depth (ft) 1541.7

728.8 m elev water table = 2391.1 ft

Thicknesses (ft)

Tpt (TSw non-welded) — 1324.6' depth
Tcb (Tac) slightly zeol — 1363.9'
Tcb (Tac welded) zeol — 1789
— 1835.7
Prow nw to partially welded

Tptpv1 — 1317.2
Tpbt1 — 1360.
Tac — 1368.6
zeol 1541
Tacbt — 1789.3
— 1832.2
Tcp (nw?) — 2083
Tcplnw zeol — 2331.4

3513 − [3932.8 − 1317.2] = 897.4

welded (TSw) ⇒ 897.4
zeol ⇒ 224.5
nw/nalt ⇒ Ø
welded (Prow) ⇒ Ø
RF 10/30/98 1122 ft

Carey et al 1997
30 Sept 97, Rev. 1
SP344BM4

Spengler et al. (1979)
USGS-OFR-79-1244

UE25p#1

elev ft 3655.0 (3654.6) RF 10/19/98
x (east) ft 571,489.52
y (north) ft ~~3655.0~~ 756,171.2 RF 8/25/00
water depth (ft) ~~3655.0~~ 1266.1 RF 8/25/00

assume 728 m water table elev (A. Armstrong interpolation)

Thicknesses (ft)

TSw (partially welded, zeolitic) 97' — 1153
Tac zeol 50' — 1250 } 113' ← 1266 water table
Tac zeol 85' — 1300
Tac (bedded) zeol 45' — 1385
— 1430
Tcp — 1570
Tcp — 1680
Tcp — 1770
Tcp (zeol) — 1792
Tcp (bedded) (zeol) — 1830
Bullfrog (nw) no zeol — 1905
Bullfrog (partially welded) — 1950
Bullfrog (welded) — 2150

Tptpv1 — 1153' depth ~~1250~~ RF 8/25/00
~~Tpbt~~ Ø RF 10/19/98 — 1250'
Tac zeol
Tacbt — 1410 — 1385'
— 1430'
Tcpunw zeol — 1530
Tcpuw — 1670
Tcplnw zeol — 1792

drift / top nw
3513 − [3655 − 1153] = 1011' ← meaningless number considering distance of well from repository

Tsw welded ⇒
zeol ⇒ 113
nw/nalt ⇒ Ø
welded (Prow & below) ⇒ Ø

Carr et al (1986)
USGS-OFR-86-175

 10/19/98 pf

WT-1

elev. ft 3942.1
x(east) ft 563739
y(north) ft 753941
water depth, ft

730.3 m watertable elev.

Thicknesses (ft)

		1309.
Tptpv3a	↕zeol	1330
Tptpv3v		1342
Tptpv1	↕zeol	1374
Tpbt1	?	1384.0
Tac	↕zeol	1564
Bullfrog		

RF 10/5/01

Carey et al. 1997
30 Sept 97, Rev 1
SP344BM

10/19/98 pf

WT-2

elev. ft 4269.9
x(east) ft 561,924
y(north) ft 760,661
water depth, ft 1872.9

730.6 m water table elev.

Thicknesses (ft)

		1222.0
Tptpv1		1293.0
Tpbt1		1303.0
Tac		1520
Taebt	↕zeol	1594
Tcpunw		1630.0
Tcpuw		1790.0
Tcplnw	↕zeol	2040

RF 10/5/01

pf 10/20/98

	Thickness (ft)
welded (Tsw)	465.1
zeol	156.9
nw/nalt	458
welded (Prow)	36
	1116

3513 − [4269.9 − 1222.0] =

Carey et al. 1997
30 Sept 97, Rev 1
SP344BM

 10/19/98 RF

G-3

water table @ 730.2 meter elev. RF 10/19/98

elev (ft)	4856.9 RF 10/19/98
x(east), ft	558,503
y (north), ft	752,690
water depth, ft	~~2309.0~~ 2461.2 RF 4/25/00

RF 10/19/98

Thicknesses (ft) ← 1309.1' depth

Unit	Thickness (ft)	Notes	Unit	Depth
				1299.2
Tsw (vitric nw)	97.2		Tptpv1	1406.4
Tsw (bedded)	6.3		Tpbt1	1412.9
Tac (vitric)	93.9		Tac	
				1506.8
Tac (bedded), ~~zeol~~ RF 10/19/98	~~65.0~~ 47.1		Tacbt	1553.9
			Tcpunw 4	1570.0
Tcp (nw)	16.1	1591' depth	Tcpuw 3	1790.0
Tcp (partial weld)	220.0	229	Tcplnw	1992.3
Tcp (zeol)	202.3	1827'	Tcbt3	1998.7
Tcp (bedded, zeol)	13.1	zeol; 1998.7 depth	Tcbunw	2040.0
		zeol to 2022.4	Tcbuw	2513.5
Bullfrog		438.8 ← water table 2461.2' depth		

welded (Tsw) ⇒

zeol ⇒	195.4 ft	250.0 ft
nw/nalt ⇒	289.0 ft	270.8 ft
welded (Prow) ⇒	667.8 ft	641.2 ft
	1152.1 ft	

Vaniman et al. (1984)
LA-9707-MS

Carey et al 1997
30 Sept 97, Rev. 1
SP344BM

RF 10/19/98

G-4

elev. ft	4166.6
x (east) ft	563,081.6 RF 10/19/98
y (north) ft	765,807.1
water depth, ft	1776

Thicknesses (ft)

——— 1353.6' depth

Unit	Thickness (ft)	Notes	Unit	Depth
				1314
			Tptpv3g (zeol)	1317
			Tptpv3v	1345.4
Tsw (vitric nw)	53.2		Tptpv2	1353.6
Tsw (bedded)	2.5		Tptpv1 (1376)	1406.8
			Tpbt1	1409.4
Tac	294.4		Tac (zeol)	1705.4
			Tacbt	1762.7
Tac (bedded)	55.7	contact @ 1756.7'	Tcpunw (water)	1791.0
		← water table (1776')	Tcpuw	1955.0
			Tcplnw	

welded (Tsw) ⇒		59.0 + ft
zeol ⇒	ft	403.0 ft
nw/nalt ⇒	ft	23.6 ft
welded (Prow) ⇒	ft RF 10/19/98	~~59~~ ∅
	ft	

Spengler et al. (1984)
USGS-OFR-84-789

 PF 10/19/98

G-2

elev ft	~~4348.6~~ 5098.0 } PF 8/25/00
x (east) ft	560,504
y (north) ft	778824
water depth, ft	

1019.4 m water table elev.

Thicknesses, ft

	1634
Tptpv3a (zeol)	1637
Tptpv3	1669
Tptpv2	1681
Tptpv1	1707
Tpbt1	1757
Tac } zeol	2576.5
Tacbt	

PF 10/5/01

Carey et al. 1997
30 Sept 97, Rev. 1
SP344BM4

PF 10/19/98

G-1

elev. ft	4348.
x (east) ft	561,000
y (north) ft	770,500
water depth, ft	1873.6

754.2 m water table elev

Thicknesses (ft)

	1360.5' depth
Tptpv1 (1396')	1403.9
Tpbt1	1425.5
Tac } zeol.	1736.4
Tacbt	1799.
Tcpunw	1880.0 (▽ 1873.6)
Tcpuw	1990.0
Tcplnw (zeol)	2154.9

PF 10/5/01

	Thickness (ft)
welded (Bw)	525.5
zeol	447.6
nw/nalt	35.5
welded (Prow)	~~110~~ Ø PF 8/25/00
	1008.6

3513 − [4348 − 1360.5] = 525.5'

Carey et al. 1997
30 Sept 97, Rev. 1
SP344BM4

 10/19/98 RF

UZ#14

elev ft 4425.4
x(east) ft 560,141
y(north) ft 771,309
water depth, ft

Thicknesses (ft)

Tptpln	1270	1279.1
Tptpv3		1358.0
Tptpv2	zed	1383.0
Tptpv1		1404.2
Tpbt1		1420.2
Tac	no data	1694
Tacbt		1750.2

RF 10/5/01

Carey et al. 1997
30 Sept 97, Rev 1
SP344BM4

RF 3/29/99
static water Table (Level) at 489.2 m (1605 ft depth) according to Table A1 in Chipera et al. 1995

RF 10/19/98

UZ#16

elev ft 4000.6
x(east) ft 564,858
y(north) ft 760,535
water depth, ft → assume elevation ≈ 730 m

Water Table expected to be at about ~1605 foot depth

borehole not drilled to water table based on Geslin et al. 1995???

Thicknesses (ft)

— 1165.2′ graphically, non to partially welded portion is about half (1165.2 to ~1183′)
Tptpv2
Tptpv1 zed. — 1201.3′
Tac zed
devitrified & also zeolite ?? → ~1442 – ~1460 } devitrified + vapor phase
several massive beds, but undivided in strat. column
zed — 1457′
Tabt zed — 1485′
Tcp
— — — 1506′ } devitrified + vapor phase; non to partial weld
zed } zeolitic, non welded
— — — 1583
water Level → 1605′ partially to mod welded
— — — 1646
zed — — — 1682 bottom

- - - approx. contacts inferred from Table A1 in Geslin et al 1995

24 mm / 100 ft

	1165.2
Tptpv1	1191.2
Tpbt1	1203.3
Tac (zed)	1455.4
Tabt1	1485.0
Tcpunw	1510.0
Tcpuw	1659.0
Tcplnw (zed)	bottom at 1684

RF 3/29/99 {Chipera, S.J., D.T. Vaniman, B.A. Carlos, and D.L. Bish. Mineralogic Variation in Drill Core UE-25 UZ#16, Yucca Mountain, Nevada, LA-12810-MS, Feb 1995, Los Alamos (lithologies based on pers. comm. with Dave Buesch according to this report)}

Basically, detailed logs (more detailed than what I recorded above) have not been published or put into technical database for UZ#16.

Note that Carey et al. 1997 has better resolution on stratigraphy than Geslin et al. 1995

Geslin et al. 1995 notes DTN: GS931208314211.047 on appendix figure of lith. column

Geslin, J.K., T.C. Moyer, D.C. Buesch, 1995
Summary of Lithologic Logging of New and Existing Boreholes at Yucca Mountain, Nevada, August 1993 to February 1994. USGS Open-File Report 94-342
Denver CO

Carey et al 1997
30 Sept 97, Rev. 1
SP344BM4

UTM (m) coordinates & Nevada State Plane coordinates along with water level data from Oliver, T., and J. Root, 1997, Hydrochemical Database for the Yucca Mountain Area, Nye County, Nevada, USGS, Memo to Technical Project Officer, SPH34BM4.

UTM(m)		Nev. State Plane (ft)		Elev(ft)	Well	Water Table Depth (m)	WT Elev (ft)
549934.75	4078317.25	566350	764900	3932.8	UE-25a#1		
551508.56	4075662.75	571485	765171	3655.0	UE-25p#1	382	2401.7
549484.44	4076985.75	564888	760535	4000.6	UZ#16		
548032.75	4080262.00	560282	771506	4429.1	UZ#14		
548298.69	4080018.00	561000	770477	4348.6	G-1		
548138.50	4082554.00	560513	778803	5098.0	G-2	534	3346.0
547550.49	4074615.75	558497	752650	4856.9	G-3		
548937.88	4078590.25	563036	765764	4166.9	G-4	541	2392.0
547536.87	4075762.00	558446	756546	4866.1	H-3	751	2402.2
549195.06	4077322.25	563904	761643	4097.0	H-4	519	2394.2
547665.44	4078837.75	558897	766624	4851.0	H-5	704	2541.3
546196.06	4077816.25	554166	763260	4270.9	H-6	526	2545.2
548384.1	4076499.	561240	758950	4470.0	SD-7		
548550.5	4079257.	561591	768058	4272.5	SD-9		
548492.2	4077415.	561606	761957	4343.0	SD-12		
549150.81	4074975.00	563739	753941	3942.1	WT-1		
548590.44	4077020.75	561924	760661	4269.9	WT-2		

KP 10/20/98

General Summary of Stratigraphy of Boreholes

vitric TSw ⇒ 3 subzones, lowest is generally non-welded though it is not always present

CHn ⇒ 3 or 4 subzones, a bedded tuff layer, and a basal sand; all of these are non-welded

Prow ⇒ upper is generally partially to non-welded
middle is generally densely welded
lower is non-welded
lowest is bedded tuff

Bullfrog ⇒ uppermost is commonly partially to non-welded

Interpolating vitric & zeol thicknesses to cover subareas

Using tecplot (version 7.0).

Since tecplot had a problem with taking subarea delineation directly out of TPA code & then contouring another data set at the same time (it wanted to contour subarea & well location at same time), I figured out that I have to make the well location & subarea lines into geometries & tack them onto the end of the interpolated data (vitric/zeol thickness) (and not at the beginning of the file, only at the end).

Tecplot also had a problem kriging the data, regardless if it was interpolating or ~~ex~~ extrapolating to a larger region [the boreholes used in the interpolating/extrapolating were chosen from near the repository footprint. Hence, inverse distance (w/ exponent of 3.5) was used in tecplot

Input files [stored in ./Zeolites/Firstcut/*

wells-subareas.plt ⇒ wells w/ data, wells w/o data, subareas } as geometries

vitricThick.plt ⇒ not interpolated, data from previous pages
zeolThick.plt ⇒ not interpolated, "
wells included G-1, H-5, SD-9, G-4, SD-12, WT-2, H-4, SD-7, G-3

Tecplot interpolated data using inverse distance & written out as ascii data files
vit-invD.plt
zeoli-invD.plt } ⟵

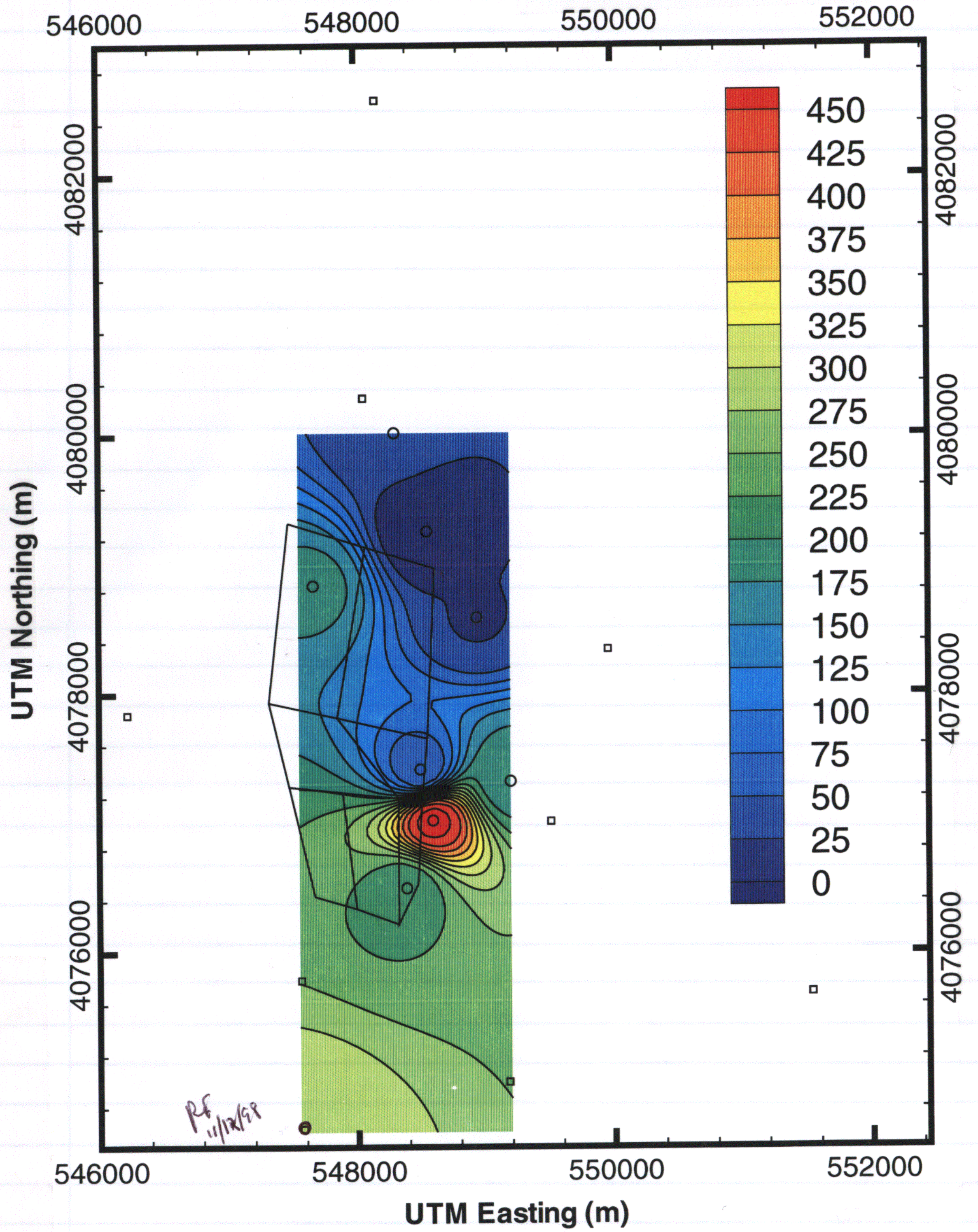
Geometries from wells-subareas.plt are attached to end of these files for the plots found on the next two pages

To interpolate the data
1. open data file, change to [2D] icon
2. Data → Create rectangle zone, 100x100, use default area
3. Data → Interpolate → inverse distance

Layout files ⇒ vit-invD.lay and zeol-invD.lay

RF 10/26/98

Vitric (non-welded) Thickness (ft) - inverse distance

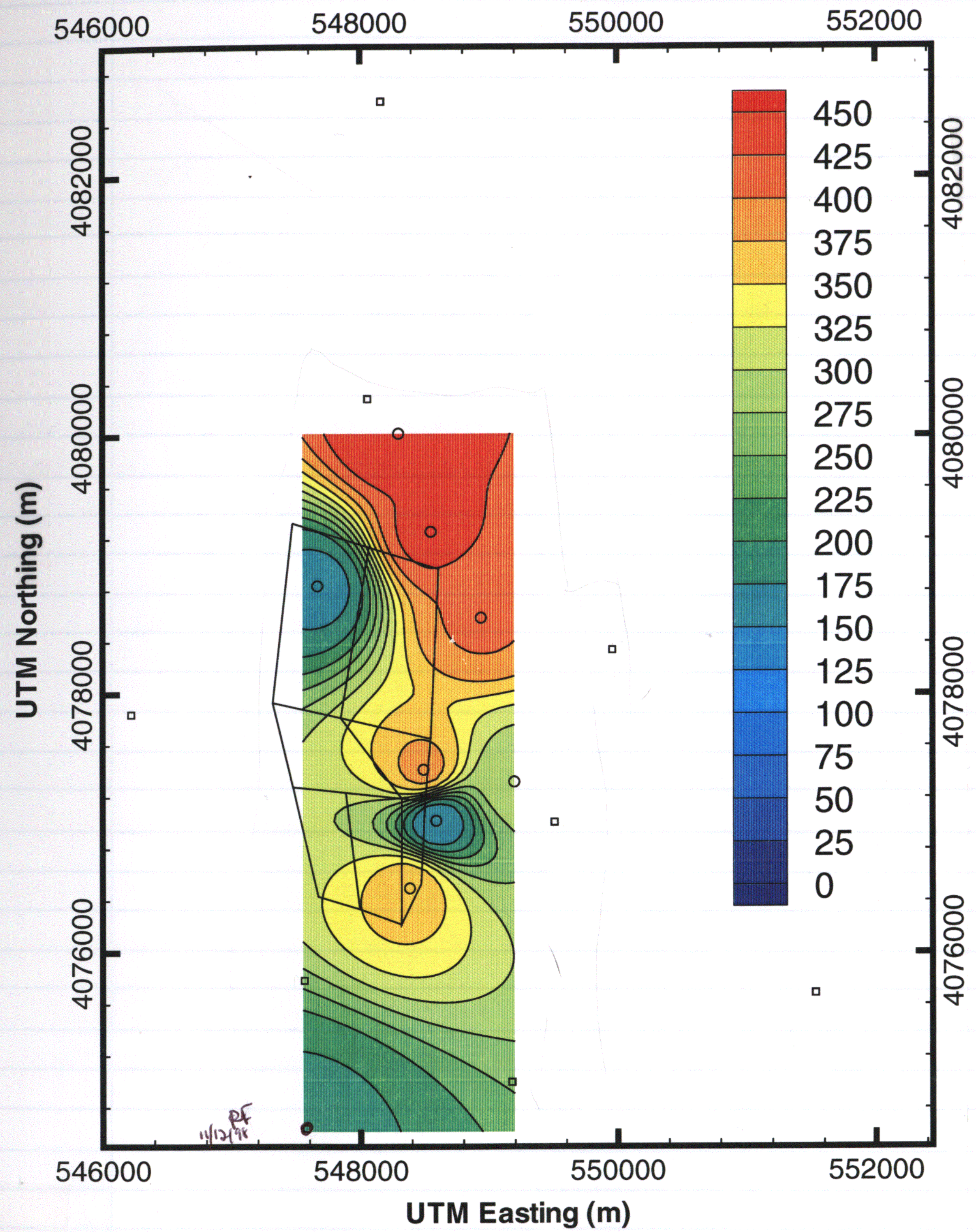


Tecplot 7.0

RF 10/30/98 o borehole used
□ borehole not used

RF 10/26/98

Zeolitic Thickness (ft) - inverse distance



Tecplot 7.0

RF 10-26-98

o borehole used
□ borehole not used

Suggestions for Improvements & Further Work

(1) Method to approx average (representative) thicknesses for each subarea. Probably print out interpolated data, bin out into each subarea, then average.

(2) Use surfer (software) to do interpolation since tecplot is choking. Problems noted with surfer:

(a) Only deals in 6-7 significant figures, hence the spatial locations must use only last 6 signif. figures

i.e. 4074508 ⟹ use 74508

Then transform after interpolation is complete

(b) must create a data reader to re-write interpolated data ~~int~~ from surfer format to column data

(3) Incorporate structure (faults) into interpolation by doing all of this in Earth Vision

(a) figure out how to extract info from Earth Vision when conformally mapping zeolites onto stratigraphy of GFM3.0 (it uses different units)

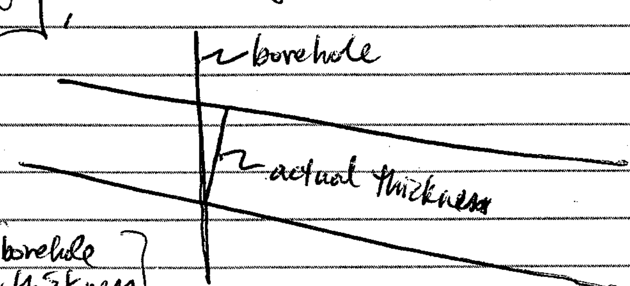
(b) maybe extract zeolitic thicknesses directly, then entire thicknesses directly (repository to water table) then subtract out non-welded → compared non-welded, interpolated thickness map to Earth Vision.

(4) Correct thicknesses for dip of stratigraphic layers. Currently, apparent thicknesses are plotted and noted; making adjustments for dip makes sense geologically, but may not make sense hydrologically [look at viewpoint of water flowing vertically through the rock layers].

insignificant for angle ≈ 5°

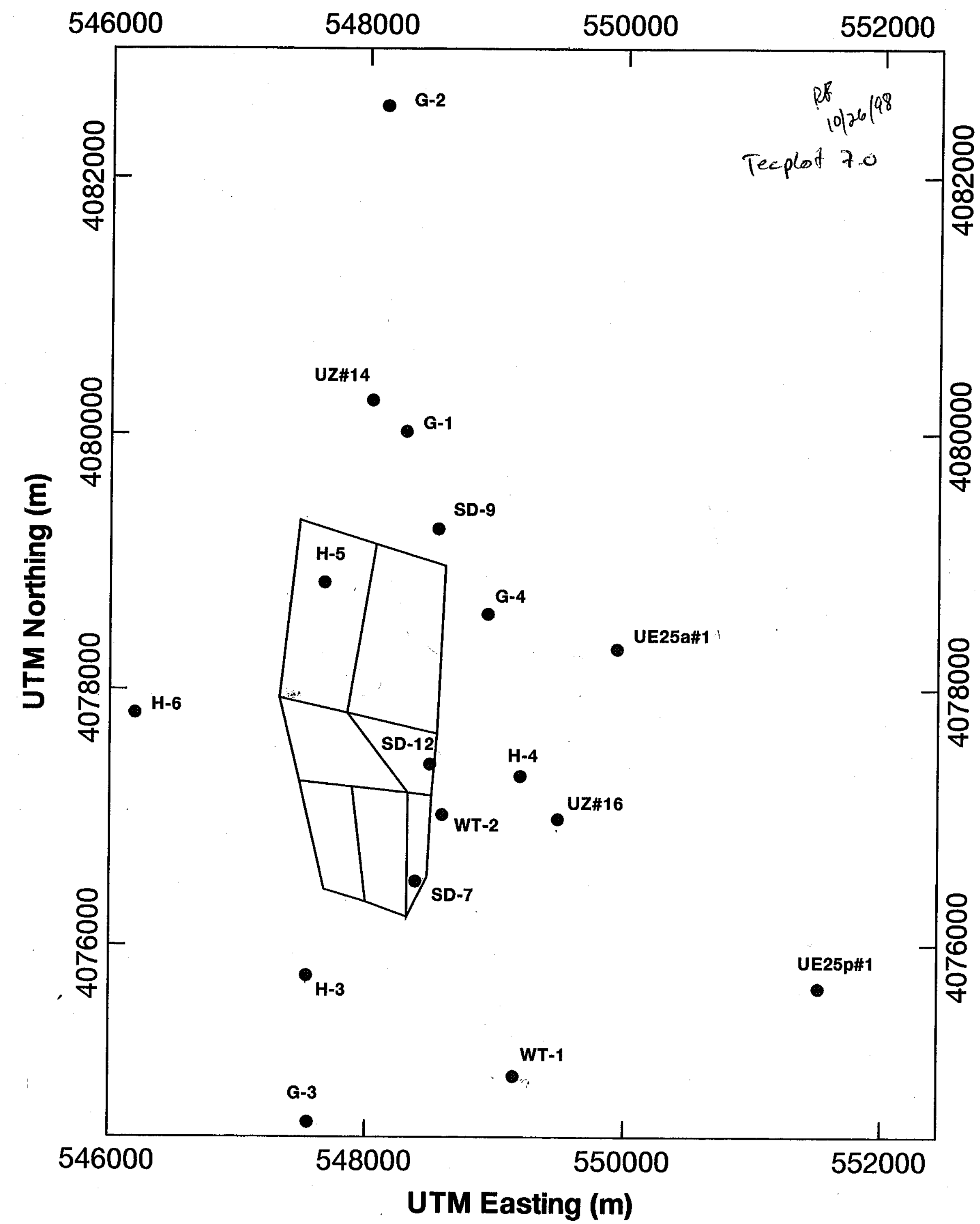
$\cos 5° = .9962$

actual thick = .9962 * [borehole thickness]



Wells currently being considered:

wells-lge.lay tecplot file



 PF 10/26/98

Wells that could be included for SAT. Zone

	depth
UE-25 p#1	to Paleozoics
SD-7	pre-Bullfrog
? ⇒ SD-9	lower Prow
? ⇒ SD-12	upper Bullfrog
UE-25 b#1	approaching Paleozoics
WT-3	upper Bullfrog
G-1, G-2, G-3	approaching Paleozoics
G-4	Pre-Bullfrog
H-1, H-3, H-4, H-5, H-6	approaching Paleozoics
J-13	Paleozoic

Aquifers (from Oliver & Root 1997) Milestone SPH34BM4

Qal	quaternary alluvium
Qtal	" - Tertiary alluvium
Tb	Tertiary basalts
Tv	Tertiary volcanic rocks
Tpt	" Topopah Spring Member of Paintbrush Tuff
Tct	" Crater Flat Tuff
Th	" tuffaceous beds of Calico Hills
Tcb	" Bullfrog Member of Crater Flat Tuff
Tcp	" Prow Pass Member of Crater Flat Tuff
Tctt	Tram Member of Crater Flat Tuff
Srm	Silurian Roberts Mountain Formation
DSlm	Devonian & Silurian Lone Mountain Dolomite

KF 10/28/98

Boreholes we want to look at during trip to YM Nov 98

(1) SD-9
- 1425 ft depth (middle of Tcptpv2, grades into nonwelded subzone)
- 2223 ft depth bottom of borehole, includes Tcp4, Tcp3, Tcp2, portion of Tcp1

(2) SD-7
- 1270 ft depth top of Tptpv2
- 1710 ft includes Tac3, Tac2, Tac1, Tacbt, Tacbs, Tcp4, and top of Tcp3 (welded)
- 1830-2180 ft Tcp2, Tcp1, Tcp (bedded)
- 2180-2598 ft Tcb (Bullfrog)
- 2598-2675 ft Tct (Tram) to bottom of hole

(3) G-3/GU-3
- GU-3 cored 10-806 m (33-2644 ft) depth
- G-3 cored 795-1533 m (2608-5030 ft) depth
- 1268 ft partially welded Tptpv2
- PF 10/28/98 → 1409 - 2000 Tac, Tcp
- 2000-2625 Tcb
- 2625-3876 Tct
- 3876-5031 Lithic Ridge & older tuffs

zeolitized @ 1827-2011 ft depth, 2546-2697 ft depth } Vaniman et al 1984 LA-9707-MS (LANL)

(4) WT-2
- 1200-2059 ft [into Tcp (lower nonwelded)]
- top of Tptpv1 is at 1222.0 ft depth
- cored 1200-1594 ft (to base of Tac)
- cuttings/sidewall cuttings 1594-2059 ft depths

The upper portion of the interval for each borehole includes the transition zone from the vitric moderately welded Tsw to the nonwelded, vitric (or altered) subzone.

SD-9 ⇒ Engstrom & Rautman 1996 (SAND96-2030); SD-7 Rautman & Engstrom (SAND96-1474)
G-3/GU-3 ⇒ Vaniman et al 1984 (LA-9707-MS); WT-2 ⇒ Carey et al 1997 (Milestone SP344BM4)

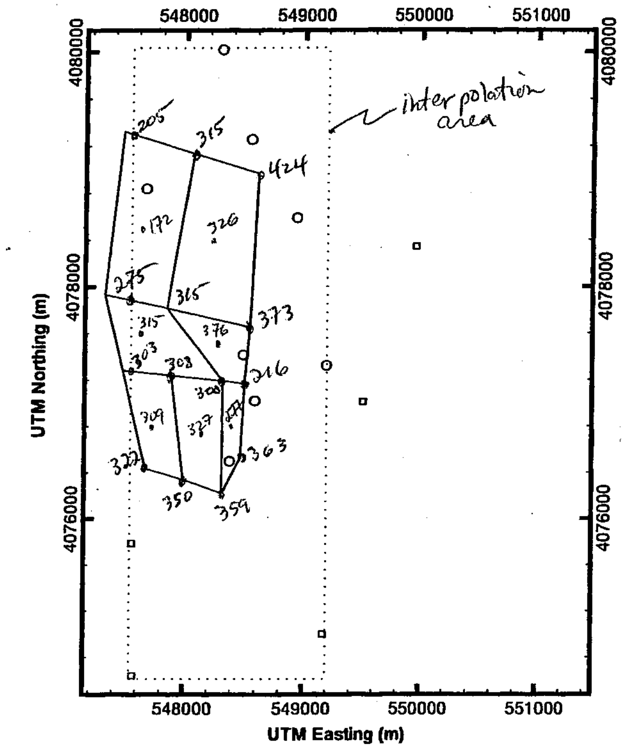
 11/9/98 RF

Estimation of representative thicknesses for each subarea

Using interpolated data from: vit-invD.lay
zeol-invD.lay
layout files from Tecplot (see page 32, 33), the representative value for thickness is taken as the average of the four corners of the center point.

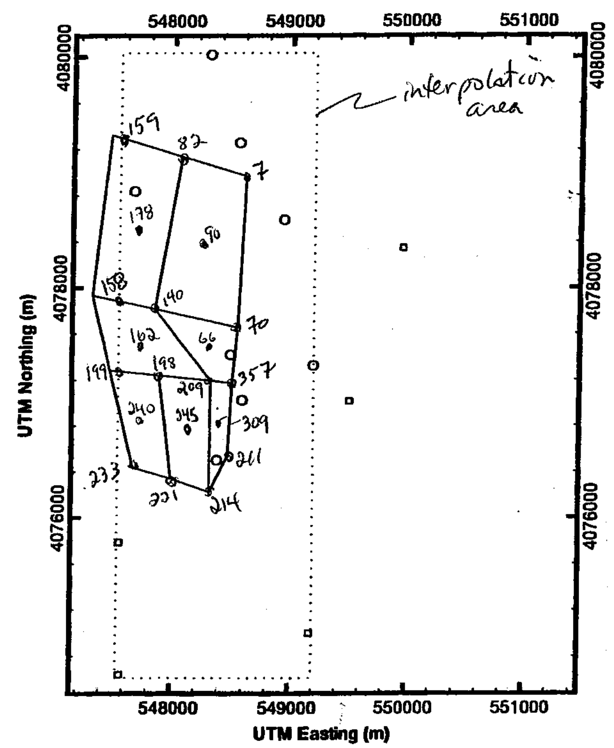
Tecplot probe tool is used to get the corners of the subareas. The center point location is taken as the simple average of the "x" and "y" locations of the corners. See bottom of page 39 for the print out of subarea node locations & calculated center location for each subarea. For the western subareas where the interpolation did not include the entire extent of subarea, the estimate uses the furthest west extent of the interpolation in the subarea.

Zeolitic horizon thickness (ft)



(Tecplot version 7.0) RF 11/13/99

nonwelded/nonaltered thickness (ft)



RF 11/9/98

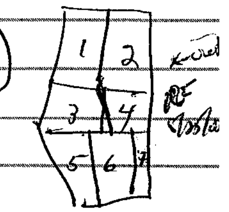
KK 2/7/00 11/9/98 RF

Preliminary 1st Cut vitric/zeolitic Thickness

	Zeolitic Horizon (ft)		Nonwelded/Nonaltered Thick (ft)		Minimum
Subarea 1	256	(78 m)	143	(44 m)	84.5 ft
Subarea 2	351	(107 m)	78	(24 m)	7 ft
Subarea 3	302	(92 m)	174	(53 m)	108.5 ft
Subarea 4	316	(96 m)	168	(51 m)	53 ft
Subarea 5	318	(97 m)	218	(66 m)	198 ft
Subarea 6	329	(100 m)	217	(66 m)	192 ft
Subarea 7	303	(92 m)	260	(79 m)	211 ft

RF 11/10/98 RF 11/10/98

(the subareas are numbered left to right, then top to bottom)



example: subarea 1 ⇒ [205 + 315 + 315 + 275 + 172] / 5 = 256

	Averages of 4 corners	Zeolite thickness (ft)	nonwelded/nonaltered thickness (ft)
ZONE T="Subarea 1"	547677 4078553	172	178
547472 4079324			
548069.2 4079137			
547847.3 4077816			
547318.4 4077934			
547472 4079324			
ZONE T="Subarea 2"			
548069.2 4079137	548269 4078394	326	90
548609.7 4078969			
548547.9 4077654			
547847.3 4077816			
548069.2 4079137			
ZONE T="Subarea 3"			
547318.4 4077934	547741 4077556	315	162
547847.3 4077816			
548322.7 4077192			
547474.7 4077282			
547318.4 4077934			
ZONE T="Subarea 4"			
547847.3 4077816	548306 4077458	376	66
548547.9 4077654			
548504.8 4077170			
548322.7 4077192			
547847.3 4077816			
ZONE T="Subarea 5"			
547474.7 4077283	547757 4076824	309	240
547887.3 4077238			
547995 4076339			
547670.4 4076436			
547474.7 4077283			
ZONE T="Subarea 6"			
547887.3 4077238	548131 4076747	327	245
548322.7 4077192			
548319.5 4076220			
547995 4076339			
547887.3 4077238			
ZONE T="Subarea 7"			
548322.7 4077192	548405 4076779	277	309
548504.8 4077170			
548473.1 4076534			
548319.5 4076220			
548322.7 4077192			

table of "center" of subarea coordinates and the associated values for nonwelded/nonaltered and zeolitic thicknesses

RF 11/9/98

Since there are sharp changes in the variations between wells SD-12, WT-2, SD-7 in the vitric thickness, the question arises: what does the interpolation look like if the well WT-2 is excluded.

New minimum values were estimated from the plot (see next page) of vitric thicknesses when WT-2 data is excluded. The probe tool in teeplot was used for this.

Subarea	Vitric Minimum Thickness (ft)	m
1	~~59.5~~ 83.6 (RF 11/25/98)	25.
2	6.7	2
3	59.2	18
4	53.0	16
5	95.1	29
6	62.0	19
7	59.5	18

The interpolation was done in the same fashion as noted on page 31.

The printout of spreadsheet tpa-thick.xls (excel) in directory d:\Randy\Zeolites\ contains the calculations for modifying the thicknesses currently used in the TPA simulations

Further refinement using EarthVision is slated for future work. Until then, defensible values are needed. The "representative values noted on page 38 will be used. Minimum values for a subarea can also be used. Since the WT-2 cuttings, and hence thickness values, bring a sharp change to the interpolation, minimum values for vitric thickness when WT-2 is excluded can also be used to create a modified table. Page 42 contains the printout of tpa-thick.xls for these scenarios. The criteria of retaining overall total thickness for UZ (repository to water table) is important since only vitric & zeolitic thicknesses were estimated in this work. The Upper Crater Flat unit in the TPA set is adjusted to insure that the total thickness remains constant.

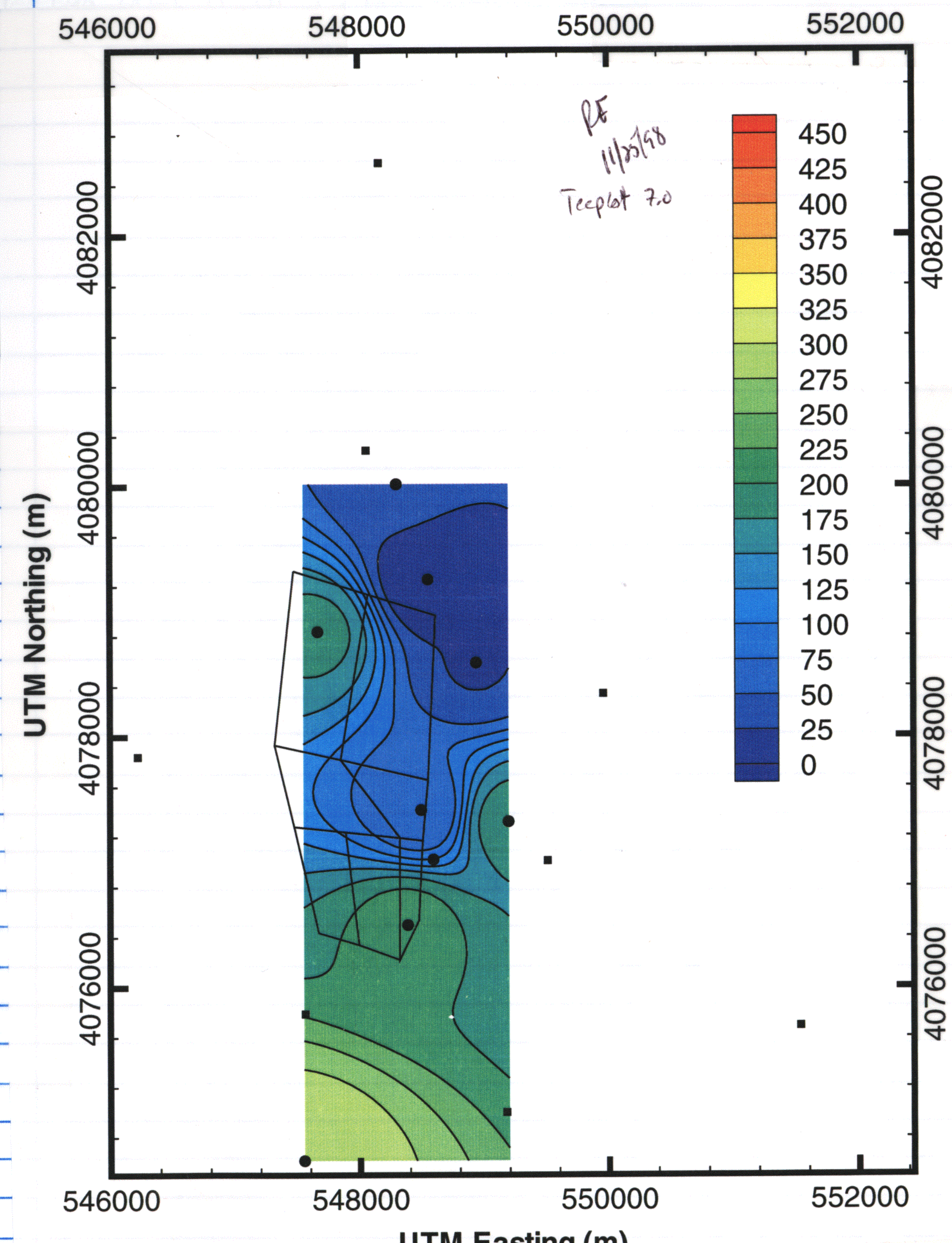


Figure 4. Interpolation of vitric horizon thickness in the unsaturated zone from 8 boreholes in the vicinity of the repository footprint excluding WT-2. Solid circles mark the boreholes included in the interpolation whereas solid squares mark boreholes not included.

11/25/98 RF

Adjusting the Upper Crater Flat was chosen since it has properties most similar to the nonwelded units. As it turns out, the "WT-2 excluded" values are just for sensitivity – modifying the tables below would necessitate changing the zeolitic interpolation also.

TPA Table for Stratigraphic Thicknesses for Each Subarea – 11/11/98 created (tpa-thick.xls)

RF 11/25/98

Base Case as of Nov10, 1998 in terms of meters

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7
	(m)	(m)	(m)	(m)	(m)	(m)	(m)
TSw	33	116	20	110	20	53	121
CHnv	0	0	0	0	113	125	0
CHnz	163	154	122	132	0	0	114
Prow Pass welded	34	39	40	34	38	26	43
Upper Crater Flat	67	20	158	57	158	136	63
Bullfrog welded	0	0	0	0	32	0	0
Total	297	329	340	333	361	340	341

Base Case as of Nov10, 1998 in terms of feet

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
TSw	108	381	66	361	66	174	397
CHnv	0	0	0	0	371	410	0
CHnz	535	505	400	433	0	0	374
Prow Pass welded	112	128	131	112	125	85	141
Upper Crater Flat	220	66	518	187	518	446	207
Bullfrog welded	0	0	0	0	105	0	0
Total	974	1079	1115	1093	1184	1115	1119

First Cut Interpolation in feet Rfedors Nov98; Use old values for everything except Calico Hills
Put representative values (5-pt avg) in for CHnv and CHnz

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
TSw	108	381	66	361	66	174	397
CHnv	143	78	174	168	218	217	260
CHnz	256	351	302	316	318	329	303
Prow Pass welded	112	128	131	112	125	85	141
Upper Crater Flat	220	66	518	187	518	446	207
Bullfrog welded	0	0	0	0	105	0	0
Total	839	1003	1191	1143	1350	1251	1308

First Cut Interpolation in feet Rfedors Nov98; Use old values for everything except Calico Hills
Put minimum values in for CHnv, use representative interpolated values for CHnv, let totals vary

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7	
	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	(ft)	
TSw	659	640	1234	846	1227	1152	951	sum of all welded
CHnv	83	7	108	53	200	210	210	minimum
CHnz	256	351	302	316	318	329	303	account for remainder of nonwelded
Prow Pass welded	0	0	0	0	0	0	0	
Upper Crater Flat	0	0	0	0	0	0	0	
Bullfrog welded	0	0	0	0	0	0	0	
Total	998	998	1644	1215	1745	1691	1464	total has changed

First Cut Interpolation in meters Rfedors Nov98; sum of all welded put in TSw
Put minimum values in for CHnv, the remainder of the total is put into nonwelded into the CHnz

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7	
	(m)	(m)	(m)	(m)	(m)	(m)	(m)	
TSw	201	195	376	258	374	351	290	sum of all welded
CHnv	25	2	33	16	61	64	64	minimum
CHnz	71	132	-69	59	-74	-75	-13	by subtraction from total
Prow Pass welded	0	0	0	0	0	0	0	
Upper Crater Flat	0	0	0	0	0	0	0	
Bullfrog welded	0	0	0	0	0	0	0	
Total	297	329	340	333	361	340	341	total same as original

First Cut Interpolation in meters Rfedors Nov98; use minimums for CHnv, representative interpolations for CHnz
Leave welded units the same as original except Upper Crater Flat is adjusted to keep totals as in original

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7	
	(m)	(m)	(m)	(m)	(m)	(m)	(m)	
TSw	33	116	20	110	20	53	121	same as original
CHnv	25	2	33	16	61	64	64	minimum
CHnz	78	107	92	96	97	100	92	representative
Prow Pass welded	34	39	40	34	38	26	43	same as original
Upper Crater Flat	127	65	155	77	113	97	21	used to keep total constant
Bullfrog welded	0	0	0	0	32	0	0	same as original
Total	297	329	340	333	361	340	341	

First Cut Interpolation in meters Rfedors Nov98; use interpolated representative values for CHnv and CHnz
Leave welded units the same as original except Upper Crater Flat is adjusted to keep totals as in original

	Subarea 1	Subarea 2	Subarea 3	Subarea 4	Subarea 5	Subarea 6	Subarea 7	
	(m)	(m)	(m)	(m)	(m)	(m)	(m)	
TSw	33	116	20	110	20	53	121	same as original
CHnv	44	24	53	51	66	66	79	representative
CHnz	78	107	92	96	97	100	92	representative
Prow Pass welded	34	39	40	34	38	26	43	same as original
Upper Crater Flat	108	43	135	41	108	95	5	used to keep total constant
Bullfrog welded	0	0	0	0	32	0	0	same as original
Total	297	329	340	333	361	340	341	

} use these for TPA modifications

Creating a Cross-Section for Ron Green → TEF
↳ 1D

Ron wanted a cross-section from the middle of the repository block to use for TEF modeling. Since the closest thing we have to a well in the middle of the repository block is the SD-6 borehole (lithologic logs not yet submitted), Ron wanted me to extract a section from the EarthVision GFM3.0 model.

Use unsliced facies files obtained from DOE by GLGP (McKague) and stored in /data1/models/GFM3~~0~~/ver3.001/GraphicalResults/*
(↑ omit RF 8/25/00)

(RF 5/4/99) → ~~GFFM~~ GFM3BHiRes.unsliced.facies
or gfm3b.unsliced.facies (lower resolution)
(no visual difference in cross-sections when using either faces file)

The facies file may be displayed and sliced using EarthVision's 3-D viewer. However, to extract grid information, create *.path, *.trv, and *.dwd (used?)

The file.path and file.trv files are loaded with the facies file into EarthVision 5.0 (started using ev & on pluto)

Visualization
↳ Cross-sections
↳ From facies files

dual-processor, 250 MHz
Silicon Graphics
MIPS R10000 Chips

The file.trv file contains info describing cross-section area.

Once files are input, plotting range specified, and min/max of Z-range adjusted, the calculate option is used

→ calculate → Cross-section plot (1)
↳ cross-section annotation (2)

The first choice, (1), plots a cross-section
The second choice, (2), prints out an ascii file with the elevations of contacts

samples illustrating the format needed for file.path and file.trv are found in /apps/dgi/ev5/data ⇒ sample.path, sample.trv

The files/cross-sections created in EarthVision appeared suspicious; The bedded tuffs in the Calico Hills, Prow, Tram, and Bullfrog were all thicker than the layers in the main parts of the respective units.

A cross-section (1D) was then extracted from the location of borehole SD-12 ⇒ 561,605.6 ft Easting and 761,956.6 ft Northing Nevada State Plane

Note that well files (*.dwd) are created by
Utilities
↳ well database operations
create New database
file → define projection
State Plane
2702 Nevada Central
units of feet
Ellipsoid: Clarke 1866
Load paths
↳ file: path
↑ see comment bottom of previous page

Back to extracting 1D cross-section info. The plots were shifted, the colors were 1 unit too high. But the annotation files had the correct information. The description of the polygons that make up the cross-section contain the correct elevations for each unit.

Hence, ron.ann file contains the grid info for the 1D column. This elevation (ft) information was put into the spreadsheet basecase97.xls, 2nd sheet and thicknesses for each unit were calculated. SD-12 stratigraphic data is from Rautman and Engstrom 1996 → SAND96-1368 (Sandia National Labs). The 1st sheet of basecase97.xls spreadsheet (excel) contains the parameter values for each layer of the dual-continuum mountain-scale UZ flow model - Berkeley from Rick Ahlers. These values were used in the technical basis documents in support of the Viability Assessement

2395 = water table elevation (ft), approx

center of repository
560,000 ft Easting
764,000 ft Northing

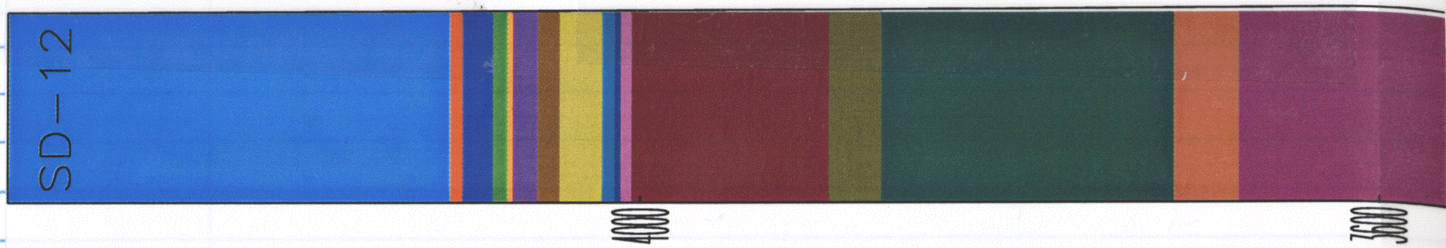
depth (ft) (tops)	elev (ft) (tops)	GFM3.0 Lithology	Hydro-stratigraphy	Thickness (ft)
0	4578	TcpLD, Tpcp	tcw11, tcw12	261
261	4317	Tpcpv3, Tpcpv2	tcw13	17
278	4300	Tpcpv1, Tpbt4	ptn21	12
290	4288	Tpy (Yucca)	ptn22	9
299	4279	Tpbt3	ptn23	19
318	4260	Tpp(Pah)	ptn24	20
338	4240	Tpbt2, Tptrv3	ptn25	44
382	4196	Tptrv2	tsw31	8
390	4188	Tptrn	tsw32	118
508	4070	Tptrl, Tptul(Tptrf)	tsw33	270
778	3800	Tptpmn	tsw34	107
885	3693	Tptpll	tsw35	314
1199	3379	Tptpln	tsw36	183
1382	3196	Tptpv3	tsw37	46
1428	3150	Tptpv2,Tptpv1,Tpbt1	ch1	91
1519	3059	Calico	ch2, ch3	172
1691	2887	Thtbt (Calicobt), Tcp4(Prowuv)	ch4	77
1768	2810	Prowuc, Prowmd, Prowlc	pp3vp	180
1948	2630	Prowlv, Prowbt, Bullfroguv	pp2zp	228
2176	2402	Bullfroguc,Bullfrogmd,Bullfroglc	bf3vp	268
2444	2134	Bullfroglv, Bullfrogbt, Tramuv	bf2zp	256
2700	1878	Tramuc, Trammd, Tramlc	tr3zp	383
3083	1495	Tramlv, Trambt, Tund	tr2zp	7748
10831	-6253	Paleozoic		

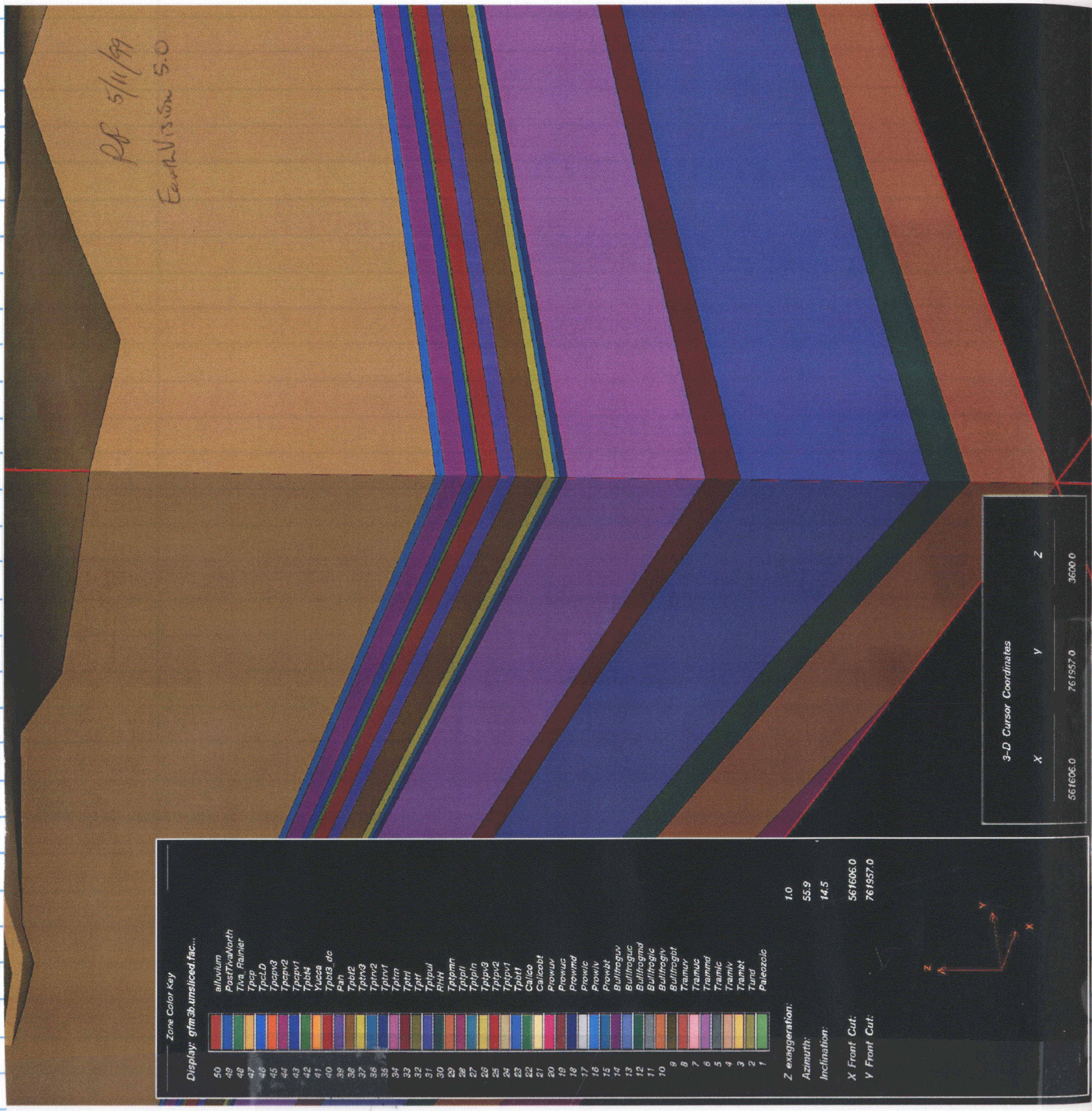
RR 5/11/99

The printout above is from basecase97.xls, sheet 2 (Thicknesses). Column 2 is from the ron.ann file, columns 1 (depth) and 5 (thickness) are calculated from column 2. The hydrostratigraphy in column 4 is used in the mountain-scale model. The correlation of the top 15 units with the GFM3.0 (column 3) units is straightforward using Table 3-4.1 of the 1997 Site-Scale Berkeley UZ flow model (Bodvarsson et al, 1997, The Site-Scale Unsaturated Flow Model of Yucca Mountain, Nevada, for the Viability Assessment, LBNL-40376, Berkeley Lab, CA)

From the Calico Hills units and downward (Prow, Bullfrog, Tram), the translation between the Berkeley flow units (col. 4) and the GFM3.0 (column 3) units is not as clean-cut. Table 3-4.1 (Bodvarsson et al 1997) again was relied upon with the distinction between, for example pp3vp and pp2zp, being primarily the degree of welding (v = vitric, c = crystalline in GFM3.0 nomenclature, Prowuc, Prowuv)
u = upper l = lower

RF 5/11/99





On page 46, the faces file on the bottom and the strat-column on the top are included here to illustrate the difference between the .plt file generated cross-sections module and the faces file rgb dump from 3D Viewer. The strat-column goes to the ground surface (4342.8 ft elev) as does the faces 3D viewer dump.

(1) The SGI monitor showed same differences, so it is not a issue of color table translation (.plt → ev_pltconvert to .ps; rgb → xv to jpeg)

(2) The high-resolution faces file had same problem: GFM3BHiRes.unsliced.faces

(3) Conclusion is that since the annotation files checked out to be correct, the problem is with the plot view garbling the colors.

7/12/99 RF

The files used to create the grid and the images are included on a zipdisk for this scientific notebook. All files mentioned between pages 43 and 47 are on the disk.

The readme.txt file on the zipdisk is included below.

RF 5/11/99

RFedors Sci. Notebk #273 May 1999

Files used to create grid information for Ron Green's 1D column near the middle of the repository footprint.

To extract a cross-section, load the faces file, .trv, .path, .dwd files into the Visualization --> cross-section --> from faces file. Calculate both the plot and the annotation file.

ron.* files are for location 560,000 ft Easting and 764,000 ft Northing Nevada State Plane.

sample.* are from /apps/dgi/ev5/data/* and are examples for proper format of EarthVision input.

sd12.* are for borehole SD-12, the closest borehole to the general location requested by Ron; This location was extracted because the bug in the cross-section plt utility led to some uncertainty in what exactly was being extracted.

gfm3b.unsliced.faces was obtained from DOE according to Larry McKague and stored in the directory /data1/models/GFM3/ver3.001/GraphicalResults/

.ps files were created from EarthVision output (.plt files) and converted using ev_pltconvert.

*.rgb files were saved from EarthVision's 3D viewer, and later converted to jpeg files using xv.

Thicknesses for TPA, UZ Unit Below Repository

Unknowns: (1) which UTM (m) spheroid was used for tpa. inputs (NAD27 or NAD83)
- subareas for natural systems
- subareas for near-field
- topo map for infilt. & soil depths
  - ↳ Stu Stothoff should have this in his Scientific Notebook from before my time at CNWRA; the file he left me (for the sub-area delineation work) had an arcinfo header UTM Clarke 1866 ellipsoid (NAD27)

RF 7/14/99

The following pages contain:
1. extraction of lithologic contacts from GFM3.1 from approx. center of each subarea
   ↳ see page 39 of this sci. notebook
2. comparison with boreholes most closely associated with each subarea
3. comparison with TPA thicknesses for each subarea

The water table position at the center of each subarea was taken from an arcinfo file prepared by Amit Armstrong using current water table data, interpolated across YM. I brought up this file in arcview and located the cursor at the center of each subarea, and interpolated the water table elevation between Amit's contours. (put on zip disk for this scientific notebook Zipdisk:\SubareaThickness\watertable*)

The extraction from GFM3.1 for subarea of the lithologic contacts was done similar to description on page 43, this book

Subareas [UTM (m)] from TPA input V3.2
Water level info interpolated as described previous page
UTM NAD27 (m) converted to StatePlane (feet) in EarthVision 5.0

.\Randy\Zeolites\Thickness\repository-7.xls
Conversion to State Plane done in EarthVision 5.0

RF 7/14/99

UTM NAD27 assumed		Averages of 4 corners UTM meters		Averages of 4 corners State Plane (feet)		Water Table June 99 Data meters	feet
ZONE T="Subarea 1"							
547472	4079324	547677	4078553	558943.4	765699.7	761.5	2498
548069.2	4079137						
547847.3	4077816						
547318.4	4077934						
547472	4079324						
ZONE T="Subarea 2"							
548069.2	4079137	548269	4078394	560884.4	765171.1	744	2441
548609.7	4078969						
548547.9	4077654						
547847.3	4077816						
548069.2	4079137						
ZONE T="Subarea 3"							
547318.4	4077934	547741	4077556	559142	762427.1	735.5	2413
547847.3	4077816						
548322.7	4077192						
547474.7	4077282						
547318.4	4077934						
ZONE T="Subarea 4"							
547847.3	4077816	548306	4077458	560995.1	762099	730.2	2396
548547.9	4077654						
548504.8	4077170						
548322.7	4077192						
547847.3	4077816						
ZONE T="Subarea 5"							
547474.7	4077283	547757	4076824	559186.2	760024.7	731.2	2399
547887.3	4077238						
547995	4076339						
547670.4	4076436						
547474.7	4077283						
ZONE T="Subarea 6"							
547887.3	4077238	548131	4076747	560412.7	759767.7	728.8	2391
548322.7	4077192						
548319.5	4076220						
547995	4076339						
547887.3	4077238						
ZONE T="Subarea 7"							
548322.7	4077192	548405	4076779	561312.2	759869.6	728.7	2391
548504.8	4077170						
548473.1	4076534						
548319.5	4076220						
548322.7	4077192						

On the following page, a print out of the EXCEL spreadsheet file (EXCEL 97 SR-2) contains the lithologic tops of each unit in the extracted columns from GFM3.1 located at approx center of each subarea. These extracted annotation files are contained on the zip disk with the EXCEL spreadsheet files
Zipdisk:\SubareaThickness\lithologies*

accidentally skipped 7/14/99

accidentally skipped RF. 7/14/99

RF 7/14/99

./Randy/Zeolites/Subareas/subareas.xls
GFM3.1 Entries are the tops of each unit, and at the center of each subarea (assumes UTM NAD27 for TPA and State Plane NAD27 for GFM3.1).

GFM3.1 units	Subarea 1 elev ft	Subarea 2 elev ft	Subarea 3 elev ft	Subarea 4 elev ft	Subarea 5 elev ft	Subarea 6 elev ft	Subarea 7 elev ft
repository	3504	3504	3546	3546	3583	3583	3583
Tptmn	3891.8	3688.4	3984.7	3763.1	4026.7	3906.6	3763.0
Tptpll	3785.5	3581.0	3846.0	3636.4	3893.3	3778.6	3633.4
Tptln	3436.7	3245.6	3541.0	3349.4	3624.5	3529.6	3380.5
Tptpv3	3292.4	3060.5	3379.9	3148.4	3472.9	3369.2	3218.6
Tptpv2	8225.5	3016.7	3337.0	3116.2	3420.4	3296.6	3146.2
Tptpv1	3212.5	3005.3	3317.6	3089.5	3382.4	3264.6	3113.2
Tptbt1	3181.4	2953.3	3277.4	3020.1	3335.6	3192.1	3047.3
Calico	3173.5	2942.2	3267.1	3011.2	3324.4	3181.0	3038.6
Thtbt(calicobt)	3013	2736.7	3152.1	2842.4	3218.4	3039.8	2863.0
Prowuv(Tcp4)	2951.7	2680.6	3102.6	2795.1	3171.5	2986.2	2801.5
Prowuc	2929.5	2652.0	3078.9	2770.1	3151.3	2969.9	2793.9
Prowmd	2807.2	2543.4	2947.2	2654.7	3019.7	2847.0	2675.9
Prowlc	2784.5	2503.2	2931.7	2609.0	2969.3	2788.1	2609.1
Prowlv	2767.2	2488.8	2907.1	2586.0	2940.1	2756.4	2580.0
Prowbt	2639.7	2279.5	2721.7	2344.2	2733.8	2503.5	2285.5
Bullfroguv	2617.8	2265.7	2702.5	2336.8	2718.1	2489.3	2272.0
Bullfroguc	2581.6	2234.3	2684.5	2308.2	2706.9		2266.3
Bullfrogmd	2480.7	2005.1	2584.1	2196.3	2664.3	2485.0	2266.3
Bullfroglc	2368.8	1891.3	2331.6	2013.1	2402.7	2229.4	2035.5
Bullfroglv	2325.8	1882.3	2309.6	1989.8	2362.9	2199.3	2003.9
Bullfrogbt	2129.1	1753.2	2185.2	1904.7	2266.5	2102.7	1913.0
Tramuv	2102.8	1731.9	2165.5	1888.8	2246.5	2085.0	1899.2
Tramuc	2001.6	1633.4	2069.8	1797.0	2170.7	2036.0	1856.3
Trammd	1942.9	1560.0	1992.3	1719.2	2080.2	1949.1	1772.9
Tramlc	1694.2	1280.7	1683.4	1375.0	1722.4	1573.8	1393.9
Tramlv	1674.3	1254.8	1659.7	1348.2	1694.3	1544.8	1365.4
Trambt	1402.2	870.9	1299.7	895.9	1274.5	1079.0	874.8
Tund	1391.4	847.3	1279.8	869.8	1244.9	1048.3	845.0
watertable	2498	2441	2413	2396	2399	2391	2391

	Subarea 1 thickness ft	H-5 Borehole	Subarea 7 thickness ft	SD-7 Borehole
TSw	278.5	308	436.8	406
CHnv	296	250.2	352.3	210
CHnz		65		150
Prow (weld)	162.3	154.9	213.9	210
Cfu (nonweld)	185.6	138.1 zeol	189	214 zeol
Bullfrog(weld)	83.6	46	0	0
water table elev	2498	2541	2391	2393
Total	1006	962.2	1133	1190

	Subarea 1 thickness ft	H-5 Borehole	Subarea 7 thickness ft	SD-7 Borehole
TSw	84.9	93.9	133.1	123.7
CHnv	90.2	76.3	107.4	64.0
CHnz	~~0.0~~	19.8	~~0.0~~	45.7
Prow (weld)	49.5	47.2	65.2	64.0
Cfu (nonweld)	56.6	42.1 zeol	57.6	65.2 zeol
Bullfrog(weld)	25.5	14.0	0.0	0.0
Total	306.6	293.3	345.3	362.7

RF 7/14/99

H-5 lithologies from Bentley et al. 1983 (see page 19 of Sci notebook)

SD-7 lithologies from Rautman & Engstrom (1996) SAND96-1474 (see page 14 of this sci notebook)

s98170_002 DATA REPORT

TABLE DESCRIPTION:
Clinoptilolite Abundance data of rock samples from USW SD-6 using X-Ray Diffraction analysis, 12/17/1997 to 05/01/1998.

TDIF: 306869

DTN: LASC831321AQ98.003

FOOTNOTES: For Clinoptilolite Abundance, % is weight %. Uncertainty is valid within two standard deviations. ND = Not Detected. Blanks are intended. Lithostratigraphy is the Buesch et al. (1996) nomenclature.

PARAMETERS AND TBV STATUS: CLINOPTILOLITE ABUNDANCE (tbv: Y)

ROW#	Q	CLINOPTILOLITE ABUNDANCE %	LOCATION	SAMPLE NUMBER	DEPTH (m)	LITHOSTRATIGRAPHY	UNCERTAINTY +/-
1	Y	ND	USW SD-6	2860p1	122.9	Tpcplnc	
2	Y	ND	USW SD-6	2861p1	126.3	Tpcplnc	
3	Y	ND	USW SD-6	2862p1	127.3	Tpcpv1-2	
4	Y	ND	USW SD-6	2863p1	128.2	Tpcpv1-2	
5	Y	ND	USW SD-6	2864p1	130.1	Tpcpv1-2	
6	Y	ND	USW SD-6	2865p1	131.1	Tpcpv1-2	
7	Y	ND	USW SD-6	2866p1	131.9	Tpcpv1-2	
8	Y	ND	USW SD-6	2867p1	132.9	Tpcpv1-2	
9	Y	ND	USW SD-6	2868p1	134.5	Tpcpv1-2	
10	Y	ND	USW SD-6	2869p1	135.5	Tpbt4	
11	Y	ND	USW SD-6	2870p1	141.5	Tpy	
12	Y	ND	USW SD-6	2975p1	442.1	Tptpln	
13	Y	3	USW SD-6	2976p1	443.8	Tptpv3	1
14	Y	ND	USW SD-6	2977p1	449.1	Tptpv3	
15	Y	ND	USW SD-6	2978p1	450.3	Tptpv3	
16	Y	ND	USW SD-6	2479p1	451	Tptpv3	
17	Y	ND	USW SD-6	2980p1	451.9	Tptpv3	
18	Y	ND	USW SD-6	2981p1	453.2	Tptpv3	
19	Y	ND	USW SD-6	2982p1	454.2	Tptpv3	
20	Y	ND	USW SD-6	2983p1	455.1	Tptpv3	
21	Y	ND	USW SD-6	2984p1	456.2	Tptpv2	
22	Y	ND	USW SD-6	2985p1	457.3	Tptpv2	
23	Y	ND	USW SD-6	2986p1	458.2	Tptpv2	
24	Y	ND	USW SD-6	2987p1	459.1	Tptpv2	
25	Y	ND	USW SD-6	2988p1	460	Tptpv2	
26	Y	ND	USW SD-6	2989p1	460.9	Tptpv2	
27	Y	ND	USW SD-6	2990p1	462.4	Tptpv1	
28	Y	ND	USW SD-6	2991p1	463.8	Tptpv1	
29	Y	ND	USW SD-6	2992p1	464.8	Tptpv1	
30	Y	ND	USW SD-6	2993p1	465.7	Tptpv1	
31	Y	ND	USW SD-6	2994p1	471.4	Tptpv1	
32	Y	4	USW SD-6	2995p1	475.8	Tac	1
33	Y	6	USW SD-6	2996p2	476.5	Tac	1
34	Y	4	USW SD-6	2996p1	476.5	Tac	1
35	Y	2	USW SD-6	2997p1	477.6	Tac	1
36	Y	1	USW SD-6	2998p1	478.7	Tac	1

RF 7/14/99

SD-6 Data on Next 3 pages

From YM data web page; ~~Table from Chad Glenn = 49~~ RF 7/14/99
Bore hole collar from Chad Glenn (Drew Coleman, DOE) ⇒ 4905.4 ft elev.

RF 7/14/99

54 7/14/99 pf

SD-6 Data

s99203_001 DATA REPORT
TABLE DESCRIPTION:
Quantitative X-Ray Diffraction (XRD) Results of Drill Core samples from USW SD-6, 02/19/1998 to 04/13/1999.
TDIF: 308227
DTN: LADV831321AQ99.001
FOOTNOTES: Percent is weight percent. -- = Not detected. Uncertainties are within two sigma. Trc. = <0.5 weight percent. Blanks are intended.
PARAMETERS AND TBV STATUS:
SMECTITE ABUNDANCE (tbv: Y)
CLINOPTILOLITE ABUNDANCE (tbv: Y)
TRIDYMITE ABUNDANCE (tbv: Y)
CRISTOBALITE ABUNDANCE (tbv: Y)
OPAL-CT ABUNDANCE (tbv: Y)
QUARTZ ABUNDANCE (tbv: Y)
FELDSPAR ABUNDANCE (tbv: Y)
GLASS ABUNDANCE (tbv: Y)
HEMATITE ABUNDANCE (tbv: Y)
MICA GROUP ABUNDANCE (tbv: Y)
HORNBLENDE ABUNDANCE (tbv: Y)
CALCITE ABUNDANCE (tbv: Y)

pf 7/14/99

NUM	Q	LOCATION	DEPTH INTERVAL ft	SPC NUMBER	SAMPLE NUMBER	SMECTITE ABUNDANCE %	SMECTITE UNCERTAINTY +/-	CLINOPTILOLITE ABUNDANCE %	CLINOPTILOLITE UNCERTAINTY +/-	TRIDYMITE ABUNDANCE %	TRIDYMITE UNCERTAINTY +/-	CRISTOBALITE ABUNDANCE %	CRISTOBALITE UNCERTAINTY +/-	OPAL-CT ABUNDANCE %	OPAL-CT UNCERTAINTY +/-	QUARTZ ABUNDANCE %	QUARTZ UNCERTAINTY +/-	FELDSPAR ABUNDANCE %	FELDSPAR UNCERTAINTY +/-	GLASS ABUNDANCE %	GLASS UNCERTAINTY +/-	HEMATITE ABUNDANCE %	HEMATITE UNCERTAINTY +/-	MICA GROUP ABUNDANCE %	MICA UNCERTAINTY +/-	HORNBLENDE ABUNDANCE %	HORNBLENDE UNCERTAINTY +/-	CALCITE ABUNDANCE %	CALCITE UNCERTAINTY +/-
1	Y	USW SD-6	379.0-379.7	SPC01006456	3247pl	--		--		--		34	2	--		3	1	61	9	--		Trc.		--		--		--	
2	Y	USW SD-6	407.8-408.3	SPC01006485	3341pl	--		--		--		36	2	--		--		58	8	--		1	1	--		--		--	
3	Y	USW SD-6	416.9-417.6	SPC01006497	3248pl	8	2	--		--		14	1	--		--		24	3	54	4	Trc.		--		Trc.		--	
4	Y	USW SD-6	427.1-427.8	SPC01006508	3342pl	26	8	--		--		3	1	--		1	1	9	1	61	8	Trc.		--		Trc.		--	
5	Y	USW SD-6	433.2-433.7	SPC01006517	3250pl	14	4	--		--		--		--		Trc.		5	1	81	4	--		--		--		--	
6	Y	USW SD-6	444.6-445.3	SPC01006529	3343pl	5	2	--		--		--		3	1	1	1	9	1	82	2	Trc.		--		--		--	
7	Y	USW SD-6	457.7-458.2	SPC01006541	3251pl	Trc.		--		--		--		--		Trc.		--		100	0	--		--		--		--	
8	Y	USW SD-6	486.7-487.3	SPC01006566	3252pl	1	1	--		--		Trc.		--		Trc.		15	2	83	2	Trc.		1	1	--		--	
9	Y	USW SD-6	496.4-497.0	SPC01006578	3344pl	14	4	--		--		--		--		Trc.		23	3	60	5	1	1	2	1	--		--	
10	Y	USW SD-6	520.5-521.1	SPC01006594	3253pl	Trc.		--		27	3	32	6	--		4	1	31	4	--		1	1	--		--		--	
11	Y	USW SD-6	530.3-531.1	SPC01006604	3345pl	--		--		11	1	13	1	--		--		69	10	--		1	1	1	1	--		1	1
12	Y	USW SD-6	547.0-547.8	SPC01006625	3254pl	--		--		6	1	12	1	--		--		79	11	--		1	1	1	1	--		--	
13	Y	USW SD-6	1420.1-1420.8	SPC01009307	3255pl	--		--		2	1	26	2	--		14	1	55	8	--		Trc.		Trc.		--		--	
14	Y	USW SD-6	1428.0-1428.9	SPC01009317	3346pl	--		--		--		16	1	--		26	2	57	8	--		Trc.		Trc.		--		--	
15	Y	USW SD-6	1432.4-1433.0	SPC01009323	3256pl	--		--		--		19	1	--		23	2	55	8	--		Trc.		Trc.		--		--	
16	Y	USW SD-6	1439.0-1439.7	SPC01009333	3257pl	--		--		--		18	1	--		24	2	57	8	--		Trc.		Trc.		--		--	
17	Y	USW SD-6	1445.1-1445.7	SPC01009341	3258pl	--		--		--		18	1	--		23	2	56	8	--		Trc.		Trc.		--		--	
18	Y	USW SD-6	1450.7-1451.4	SPC01009351	3259pl	--		--		--		12	1	--		29	2	55	8	--		Trc.		Trc.		--		--	
19	Y	USW SD-6	1470.6-1471.4	SPC01009358	3260pl	--		--		--		--		3	1	1	1	4	1	92	1	--		Trc.		--		--	
20	Y	USW SD-6	1477.4-1478.2	SPC01009368	3347pl	--		--		--		--		10	2	1	1	7	1	80	3	--		Trc.		--		2	1
21	Y	USW SD-6	1482.9-1483.5	SPC01009378	3261pl	--		--		--		--		10	2	1	1	7	1	82	2	--		Trc.		--		--	
22	Y	USW SD-6	1487.4-1488.3	SPC01009386	3348pl	--		--		--		--		7	2	1	1	5	1	87	2	--		Trc.		--		--	
23	Y	USW SD-6	1493.9-1494.7	SPC01009396	3262pl	--		--		--		--		17	4	1	1	10	1	72	4	--		Trc.		--		--	
24	Y	USW SD-6	1502.6-1503.3	SPC01009408	3349pl	Trc.		--		--		--		13	3	1	1	8	1	78	3	--		Trc.		--		--	
25	Y	USW SD-6	1508.7-1509.2	SPC01009417	3263pl	2	1	--		--		--		14	4	1	1	11	2	71	4	--		Trc.		--		1	1
26	Y	USW SD-6	1521.8-1522.4	SPC01009430	3264pl	4	1	--		--		--		4	1	1	1	6	1	85	2	--		Trc.		--		--	
27	Y	USW SD-6	1546.8-1547.5	SPC01009445	3265pl	--		--		--		--		1	1	Trc.		2	1	97	1	--		Trc.		--		--	
28	Y	USW SD-6	1561.1-1561.7	SPC01009450	3350pl	Trc.		16	1	--		--		5	2	31	2	47	7	--		--		--		--		--	
29	Y	USW SD-6	1567.0-1567.8	SPC01009460	3266pl	1	1	Trc.		--		--		8	2	4	1	19	3	68	3	Trc.		--		--		--	
30	Y	USW SD-6	1574.2-1574.8	SPC01009469	3351pl	Trc.		2	1	--		--		3	1	4	1	14	2	77	2	Trc.		Trc.		--		--	
31	Y	USW SD-6	1584.7-1585.4	SPC01009479	3267pl	Trc.		--		--		--		3	1	2	1	7	1	88	1	Trc.		Trc.		--		--	
32	Y	USW SD-6	1629.5-1630.2	SPC01009495	3268pl	--		--		--		--		3	1	3	1	8	1	86	1	--		--		--		--	
33	Y	USW SD-6	1711.2-1712.0	SPC01009499	3269pl	14	4	2	1	--		2	1	--		4	1	24	3	47	5	1	1	2	1	1	1	3	1
34	Y	USW SD-6	1714.3-1715.0	SPC01009503	3352pl	17	5	3	1	--		3	1	--		7	1	33	5	34	7	Trc.		1	1	1	1	1	1
35	Y	USW SD-6	1726.9-1727.8	SPC01009511	3270pl	--		--		--		1	1	--		3	1	16	2	80	2	Trc.		Trc.		--		--	
36	Y	USW SD-6	1738.3-1739.0	SPC01009520	3353pl	3	1	--		--		1	1	--		4	1	13	2	75	3	Trc.		Trc.		--		4	1
37	Y	USW SD-6	1744.1-1744.7	SPC01009527	3271pl	Trc.		--		--		15	1	--		24	2	56	8	--		1	1	Trc.		--		--	
38	Y	USW SD-6	1750.2-1750.8	SPC01009536	3354pl	Trc.		--		4	1	13	1	--		20	2	58	8	--		1	1	Trc.		--		--	
39	Y	USW SD-6	1756.4-1757.1	SPC01009545	3272pl	1	1	--		4	1	13	1	--		17	1	59	8	--		1	1	Trc.		--		--	
40	Y	USW SD-6	1763.2-1763.9	SPC01009553	3355pl	2	1	--		8	1	10	1	--		19	1	59	8	--		2	1	Trc.		--		--	
41	Y	USW SD-6	1768.6-1769.3	SPC01009561	3356pl	2	1	--		8	1	5	2	--		26	2	60	8	--		1	1	Trc.		--		--	
42	Y	USW SD-6	1774.9-1775.8	SPC01009571	3357pl	1	1	--		9	1	5	2	--		25	2	60	8	--		1	1	1	1	--		--	
43	Y	USW SD-6	1781.0-1781.9	SPC01009579	3358pl	1	1	--		11	1	3	1	--		27	2	61	9	--		1	1	Trc.		--		--	
44	Y	USW SD-6	1788.7-1789.4	SPC01009587	3359pl	2	1	--		9	1	3	1	--		27	2	61	9	--		1	1	Trc.		--		--	
45	Y	USW SD-6	1799.8-1800.6	SPC01009596	3360pl	2	1	--		9	1	2	1	--		29	2	60	8	--		1	1	1	1	--		--	
46	Y	USW SD-6	1808.2-1809.1	SPC01009604	3361pl	2	1	--		11	1	2	1	--		26	2	59	8	--		1	1	Trc.		--		--	
47	Y	USW SD-6	1821.2-1821.9	SPC01009635	3362pl	2	1	--		10	1	7	3	--		23	2	61	9	--		Trc.		1	1	--		--	
48	Y	USW SD-6	1827.1-1827.7	SPC01009646	3363pl	2	1	--		9	1	7	3	--		21	2	58	8	--		Trc.		Trc.		--		--	
49	Y	USW SD-6	1836.0-1836.7	SPC01009656	3364pl	2	1	--		7	1	8	3	--		20	2	60	8	--		Trc.		Trc.		--		--	
50	Y	USW SD-6	1849.5-1850.3	SPC01009668	3365pl	2	1	--		4	1	10	1	--		23	2	61	9	--		--		Trc.		--		--	
51	Y	USW SD-6	1856.4-1857.1	SPC01009677	3366pl	1	1	--		3	1	12	1	--		20	2	63	9	--		--		Trc.		--		--	
52	Y	USW SD-6	1865.0-1865.7	SPC01009687	3367pl	2	1	--		3	1	16	1	--		18	1	62	9	--		--		Trc.		--		--	
53	Y	USW SD-6	1876.0-1876.8	SPC01009707	3368pl	2	1	--		2	1	21	2	--		12	1	64	9	--		--		Trc.		--		--	
54	Y	USW SD-6	1882.2-1882.9	SPC01009715	3369pl	3	1	--		--		26	2	--		9	1	61	9	--		--		Trc.		--		--	
55	Y	USW SD-6	2123.3-2124.0	SPC01009976	3370pl	--		--		3	1	34	2	--		5	1	52	7	--		1	1	1	1	--		--	
56	Y	USW SD-6	2129.8-2130.5	SPC01009956	3371pl	--		--		--		10	1	--		30	2	56	8	--		1	1	2	1	--		--	
57	Y	USW SD-6	2139.7-2140.3	SPC01009969	3372pl	--		--		2	1	6	2			29	2	58	8	--		1	1	1	1	--			

s98430_001 DATA REPORT

TABLE DESCRIPTION:
Lithostratigraphy data of unsaturated zone lithostratigraphic contacts from borehole USW SD-6, 07/18/1998 to 08/18/1998.

TDIF: 307376
DTN: SNF40060298001.001

UTM (m) 547592 4,077,514 (from boreholelst.upd Darrell Simms) RF 7/14/99

FOOTNOTES: In USW SD-6, the Tcpm is not well developed. The density log indicates the rocks are in the upper part of the partially welded subzone to lower part of the moderately welded subzone and crystallized. The Tcpm unit could be modeled as absent in this location if unit density and calculated porosity are the dominant modeling parameters. In USW SD-6, the vitric-zeolitic boundary occurs within the crystallized part of the Prow Pass Tuff; therefore, no value was identified. In the Contact Depth column, the abbreviation no-temp td indicates the unit was not penetrated because of temporary total depth of borehole in superjacent unit. Blanks are intended. Attributal Lithostratigraphy is the Buesch et al. (1996) nomenclature.

PARAMETERS AND TBV STATUS: LITHOSTRATIGRAPHY (tbv:)

ROW#	Q	LITHOSTRATIGRAPHY	LOCATION	LITHOSTRATIGRAPHY	CONTACT DEPTH (ft)
1	Y	Not described	USW SD-6	ND	0.0
2	Y	alluvium	USW SD-6	Qa	0.0
3	Y	Rainier Mesa Tuff, includes pre-Rainier Mesa Tuff bedded tuff	USW SD-6	Tmr	0.0
4	Y	rhyolite of Comb Peak	USW SD-6	Tpk	0.0
5	Y	Tiva Canyon Tuff (Tpc) nondivided	USW SD-6	Tpc_un	0.0
6	Y	Tpc, crystal-poor vitric densely welded subzone	USW SD-6	Tpcpv3	414.6
7	Y	Tpc, crystal-poor vitric moderately welded subzone	USW SD-6	Tpcpv2	414.6
8	Y	Tpc, crystal-poor vitric nonwelded to partially welded subzones	USW SD-6	Tpcpv1	429.0
9	Y	pre-Tiva Canyon Tuff bedded tuff	USW SD-6	Tpbt4	442.4
10	Y	Yucca Mountain Tuff nondivided	USW SD-6	Tpy	445.0
11	Y	pre-Yucca Mountain Tuff bedded tuff	USW SD-6	Tpbt3	466.4
12	Y	Pah Canyon Tuff nondivided	USW SD-6	Tpp	480.0
13	Y	pre-Pah Canyon Tuff bedded tuff	USW SD-6	Tpbt2	488.8
14	Y	Topopah Spring Tuff (Tpt) crystal-rich vitric nonwelded to partially welded zones	USW SD-6	Tptrv3	517.4
15	Y	Tpt, crystal-rich vitric moderately welded zone	USW SD-6	Tptrv2	520.7
16	Y	Tpt, crystal-rich vitric densely welded zone	USW SD-6	Tptrv1	525.7
17	Y	Tpt, crystal-rich nonlithophysal zone	USW SD-6	Tptrn	527.4
18	Y	Tpt, crystal-rich lithophysal zone	USW SD-6	Tptrl	632.0
19	Y	Tpt, lithic-rich zone	USW SD-6	Tptf	645.7
20	Y	Tpt, crystal-poor upper lithophysal zone	USW SD-6	Tptpul	645.7
21	Y	Tpt, crystal-poor middle nonlithophysal zone	USW SD-6	Tptpmn	853.0
22	Y	Tpt, crystal-poor lower lithophysal zone	USW SD-6	Tptpll	995.0
23	Y	Tpt, crystal-poor lower nonlithophysal zone	USW SD-6	Tptpln	1305.0
24	Y	Tpt, crystal-poor vitric densely welded subzone	USW SD-6	Tptpv3	1456.0
25	Y	Tpt, crystal-poor vitric moderately welded subzone	USW SD-6	Tptpv2	1503.0
26	Y	Tpt, crystal-poor vitric nonwelded to partially welded subzones	USW SD-6	Tptpv1	1520.0
27	Y	pre-Topopah Spring Tuff bedded tuff	USW SD-6	Tpbt1	1552.0
28	Y	Calico Hills Formation undifferentiated	USW SD-6	Tac	1561.0
29	Y	pre-Calico Hills Formation bedded tuff	USW SD-6	Tacbt	1664.0
30	Y	Prow Pass Tuff (Tcp) upper vitric(zeolitic) nonwelded to partially welded zones	USW SD-6	Tcpuv	1715.0
31	Y	Tcp, upper crystallized nonwelded to partially welded zones	USW SD-6	Tcpuc	1739.9
32	Y	Tcp, crystallized moderately to densely welded zones	USW SD-6	Tcpm	1872.0
33	Y	Tcp, lower crystallized nonwelded to partially welded zones	USW SD-6	Tcplc	1885.0
34	Y	Tcp, lower vitric(zeolitic) nonwelded to partially welded zones	USW SD-6	Tcplv	1908.0
35	Y	pre-Prow Pass Tuff bedded tuff	USW SD-6	Tcpbt	2081.0
36	Y	Bullfrog Tuff (Tcb) upper vitric(zeolitic) nonwelded to partially welded zones	USW SD-6	Tcbuv	2103.0
37	Y	Tcb, upper crystallized nonwelded to partially welded zones	USW SD-6	Tcbuc	2122.4
38	Y	Tcb, crystallized moderately to densely welded zones	USW SD-6	Tcbm	2217.0
39	Y	Tcb, lower crystallized nonwelded to partially welded zones	USW SD-6	Tcblc	2477.0
40	Y	Tcb, lower vitric(zeolitic) nonwelded to partially welded zones	USW SD-6	Tcblv	2506.0
41	Y	pre-Bullfrog Tuff bedded tuff	USW SD-6	Tcbbt	np-temp td
42	Y	Tram Tuff (Tct) upper vitric(zeolitic) nonwelded to partially welded zones	USW SD-6	Tctuv	
43	Y	Tct, upper crystallized nonwelded to partially welded zones	USW SD-6	Tctuc	
44	Y	Tct, crystallized moderately to densely welded zones	USW SD-6	Tctm	
45	Y	Tct, lower crystallized nonwelded to partially welded zones	USW SD-6	Tctlc	
46	Y	Tct, lower vitric(zeolitic) nonwelded to partially welded zones	USW SD-6	Tctlv	
47	Y	pre-Tram Tuff bedded tuff	USW SD-6	Tctbt	
48	Y	lower Tertiary units undifferentiated	USW SD-6	Tund	
49	Y	Palezoic and older units	USW SD-6	Pz	
50	Y	Vitric-Zeolitc boundary (noncrystallized rocks, pervasively vitric versus zeolitic)	USW SD-6	V-Z	

Lithologic Contacts SD-6

TDIF data web page

7/14/99 RF

NEW SUBAREAS – (10)

PA folks took the EDA II design-based coordinates I gave them (see page 58 of Scientific Notebook #294), and created new subareas (see figure on next page). Sitakanta requested that I give them new layer thicknesses and hydrologic properties. My plans are to:

1. Use GFM3.1 to get layer thicknesses for the center of each new and old subarea (consistency!)
2. Transform the thicknesses of GFM3.1 layers to the hydrostratigraphy of the TPA code
3. Get water table height from Amit Armstrong's interpolation from July 1999 for total thickness of UZ below the repository
4. Interpolate vitric & zeolitic thicknesses from my old interpolations; see page 39 of this notebook for methodology.

For step (1.), obtaining thicknesses from EarthVision GFM3.1 model, I had to convert the spatial coordinates from Ron Janetzke in UTM NAD27 (m) to StatePlane NAD27 (~~feet~~ ft) used in GFM3.1

RF 2/7/00 Conversions of centers of each subarea (average of 4 corners) was confirmed by loading DOE's original data file of drift coordinates [which was in State Plane NAD27 (~~m~~ ft)] RF 8/25/00 ~~and noting the feet to meters conversion.~~

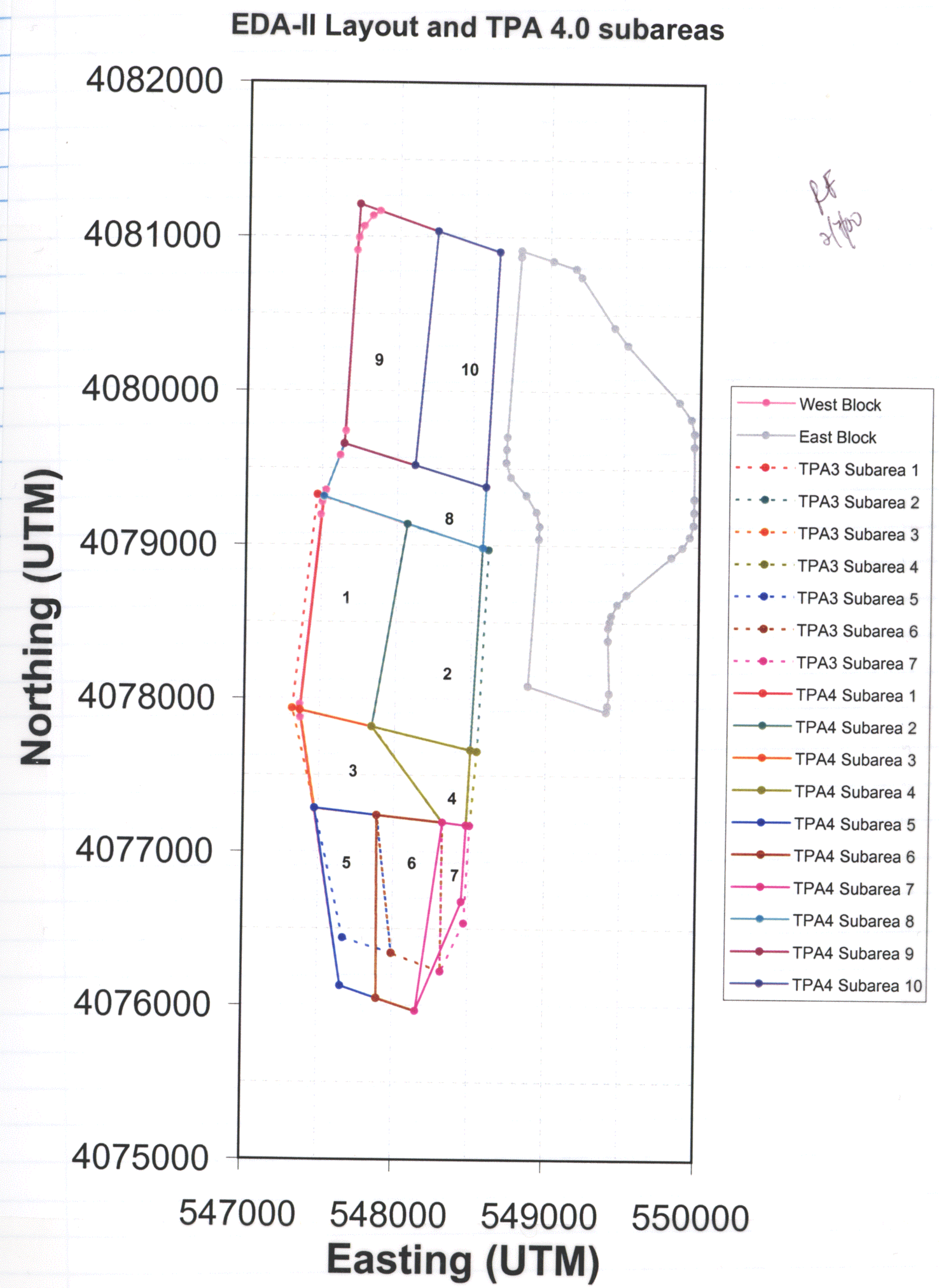
RF 2/7/00 DOE original data was in meters!; No they were in feet!!

bubo D:\Randy\Zeolites\NewSubAreasFeb2000*

RF 8/25/00 The spreadsheet Ron Janetzke gave me ⇒ subareas.xls (1st 3 sheets). I modified this by using EXCEL 97_2 by creating a 4th sheet (labeled = rfedors) and calculating centerpoints, putting in RF 8/25/00 UTM to State Plane converted points. A printout of the sheet is found on page 58.

The conversion was also confirmed in EarthVision 5.0 using their utility for converting single data locations.

Ron Janetzke's figure from subareas.xls



RF 2/7/00

 2/7/00 RF

Sheet "rfedors" (4th one) in subareas.xls

RFedors Feb 7, 2000

Centers of 10 subareas for TPA 4.0

RF 2/7/00

			UTM Easting meters	UTM Northing meters	State Plane Easting feet	State Plane Northing feet
new 1-cw						
	547514.88	4079311	547700.6	4078546	559020.8	765676.4
	548069.2	4079137				
	547847.3	4077816				
	547370.95	4077922				
	547514.88	4079311				
new 2-cw						
	548069.2	4079137	548247.5	4078399	560813.9	765187.7
	548569.32	4078981				
	548504.06	4077664				
	547847.3	4077816				
	548069.2	4079137				
new 3-cw						
	547370.95	4077922	547753.9	4077553	559184.4	762417.1
	547847.3	4077816				
	548322.7	4077192				
	547474.7	4077282				
	547370.95	4077922				
new 4-cw						
	547847.3	4077816	548288.4	4077461	560937.4	762109
	548504.06	4077664				
	548479.71	4077173				
	548322.7	4077192				
	547847.3	4077816				
new 5-cw						
	547474.7	4077283	547728.9	4076672	559092.2	759526.2
	547887.3	4077238				
	547897.79	4076045				
	547655.97	4076123				
	547474.7	4077283				
new 6-cw						
	547887.3	4077238	548065.9	4076610	560197.5	759318.8
	548322.7	4077192				
	548155.7	4075963				
	547897.79	4076045				
	547887.3	4077238				
new 7-cw						
	548322.7	4077192	548353.3	4076751	561142.2	759778.3
	548479.71	4077173				
	548455	4076675				
	548155.7	4075963				
	548322.7	4077192				
new 8-cw						
	547645.27	4079656	548079.6	4079331	560273.6	768248.2
	548588.98	4079378				
	548569.32	4078981				
	547514.88	4079311				
	547645.27	4079656				
new 9-cw						
	547732.82	4081208	547936.7	4080354	559816.3	771607.1
	548251.91	4081035				
	548116.89	4079517				
	547645.27	4079656				
	547732.82	4081208				
new 10-cw						
	548251.91	4081035	548405.6	4080208	561353.5	771122.6
	548664.55	4080902				
	548588.98	4079378				
	548116.89	4079517				
	548251.91	4081035				

RF 2/7/00

To extract the stratigraphic column out of EarthVision GFM 3.1, create *.path for for each center point of all 10 subareas. In the example below, a traverse distance is needed (it cannot be a vertical cross-section) so I use a traverse distance of 0.6 meters from top of column to bottom. This does not affect the results, but it does get around EarthVision's demand for traverse being non-zero.

sa-1.path

```
# Type: well paths
# Version: 3
# Format: fixed
# Field: x 1 12
# Field: y 13 24
# Field: wellid 25 34 non-numeric
# Field: tvdss 35 41
# Field: linecol 42 44
# Field: symbol 46 47 non-numeric
# Field: commonid 51 70
# Projection: State Plane
# Zone: 2702 -- Nevada (Central)
# Units: feet
# Ellipsoid: Clarke 1866
# End:
  559020.80  765676.10  SA-1    5000. 13  2   SubArea
  559020.80  765676.40  SA-1    2500.
  559020.80  765676.70  SA-1       0.        SubArea
```

RF 2/7/00

The output of Visualization → Cross-sections → from facies files commands in EarthVision are *.ann files with vertical coordinates of each layer boundary. I used the same facies file and procedure as used on page 43 of this notebook, except that no *.tpv file is needed. The sa-1.ann and sa-1.path files along with all others for the other subareas were transferred to bubo, the NTbox in my office

bubo : D:\Randy\Zeolites\NewSubAreasFeb2000*
in the \GFM3-1 directory

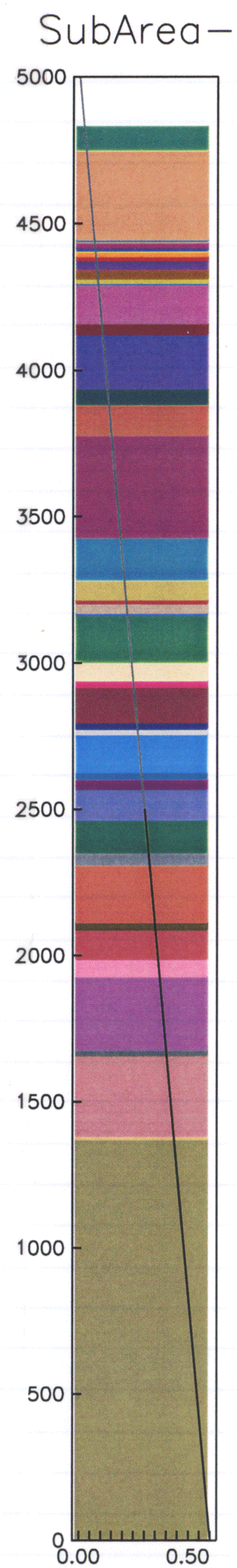
These files were also stored on pluto: ~/rfedors/SubAreasFeb2000/*

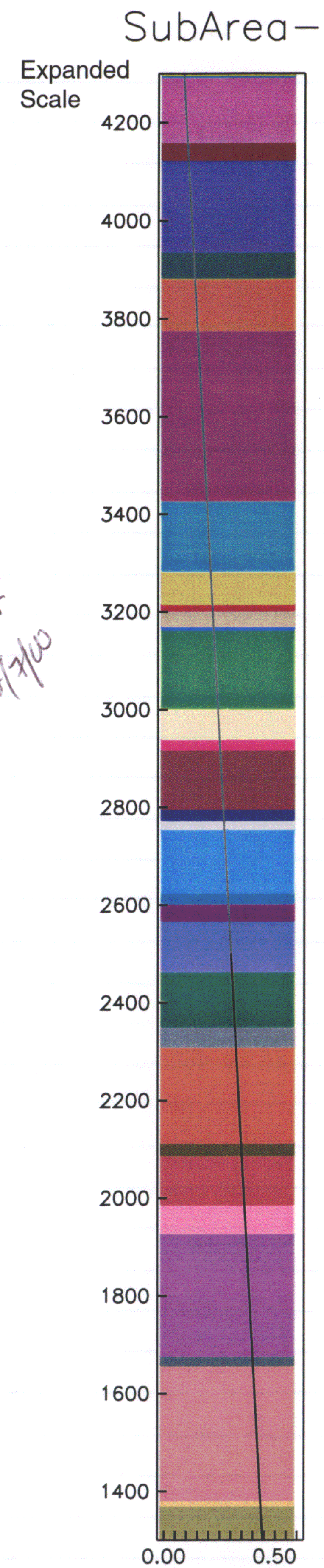
The stratigraphic columns (one is expanded version of the other) on the next page are useful in interpreting the sa-?.ann files, which are just descriptions of polygons in the stratigraphic column.

Elevations are in feet for the annotation files (*.ann)

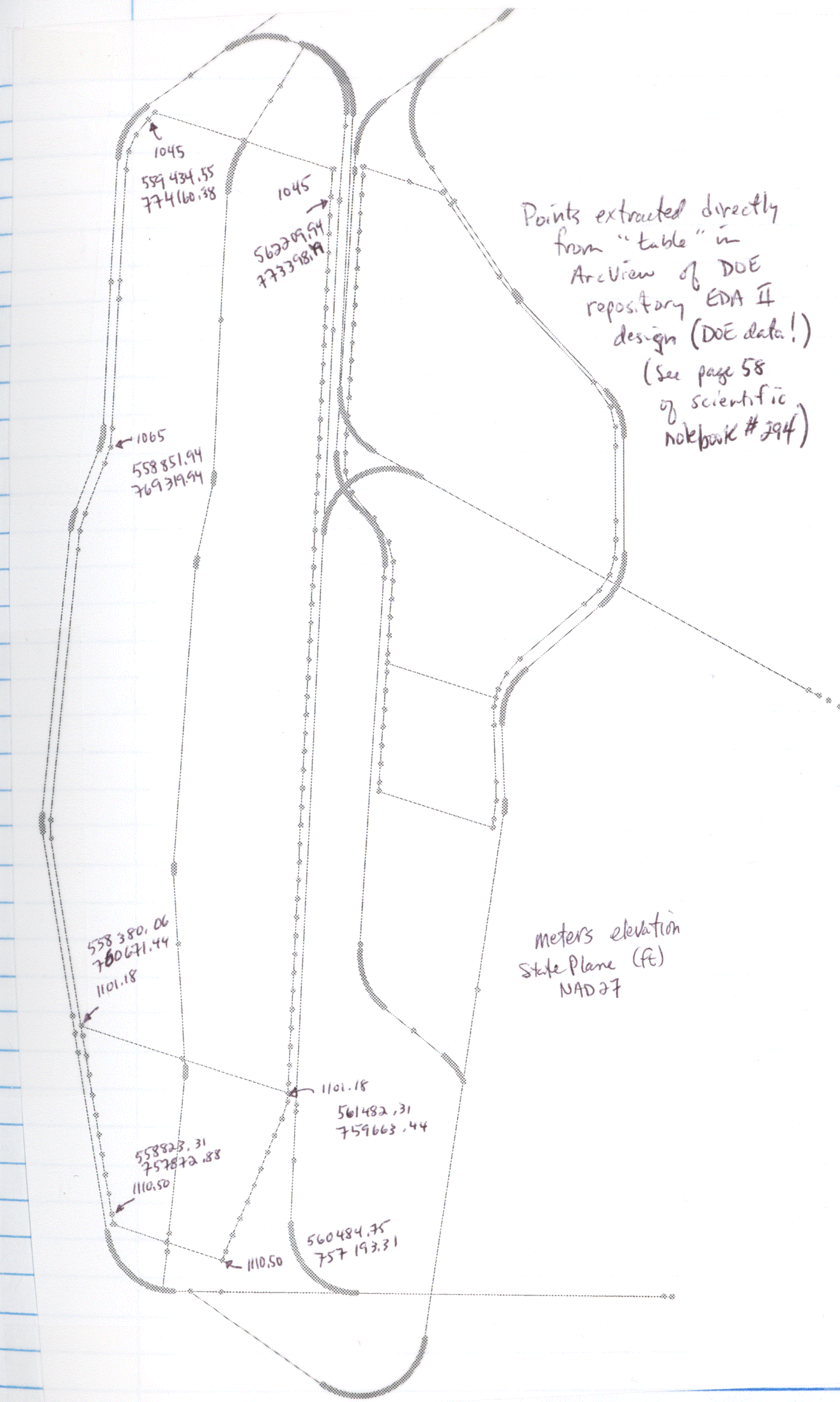
The layer contacts are included in the table on page ~~63~~ 65 RF 2/8/00

RF 2/7/00





RF 2/7/00



Assume East-West slope of drift is horizontal (the data points support this)

Then account for North-South slope with simple linear slope adjustment

$$\text{slope} = \frac{1110.5 - 1045}{757872 - 774160}$$

$= -0.0040214$

Using this approximation, the point at elev. 1065 and coordinates 558851.9 769319.9 is predicted as 1064.5

elev = slope [ΔY] ← from north horizontal measure

See discussion next page

RF 2/7/00

The EarthVision annotation files give the layer contact elevations, the simple approximation method shown on page 61 gives the drift elevation at any position within the repository (drift) footprint. All that is needed to complete the thicknesses is to approximate the water table position. Although a flat water table at 730 m elevation could be assumed, we know that H-5 in the NW corner of the drift area footprint is at 775 m elev.

I will use Amit Armstrong's water table interpolation (refined interpolation near the repository) from July 1999. See his notebook for details. Using the cursor in ArcView 3.1, after loading the files in

bubo: D:\AVData\watertable\water1.apr

at the centers of the subareas, a water table elevation is visually estimated from the 1 m contour interval map.

The water table interpolation use UTM NAD27 (m). Drift elevation estimate is in meters. Both of these needed to be converted for entry into the table.

	Elev Drift (m)	Elev Water Table (m)
SubArea-1	1080.7	761
-2	1092.8	744
-3	1094.5	735
-4	1095.8	730
-5	1106.7	732
-6	1107.5	729
-7	1105.6	729
-8	1069.9	762
-9	1055.8	789
-10	1057.8	783

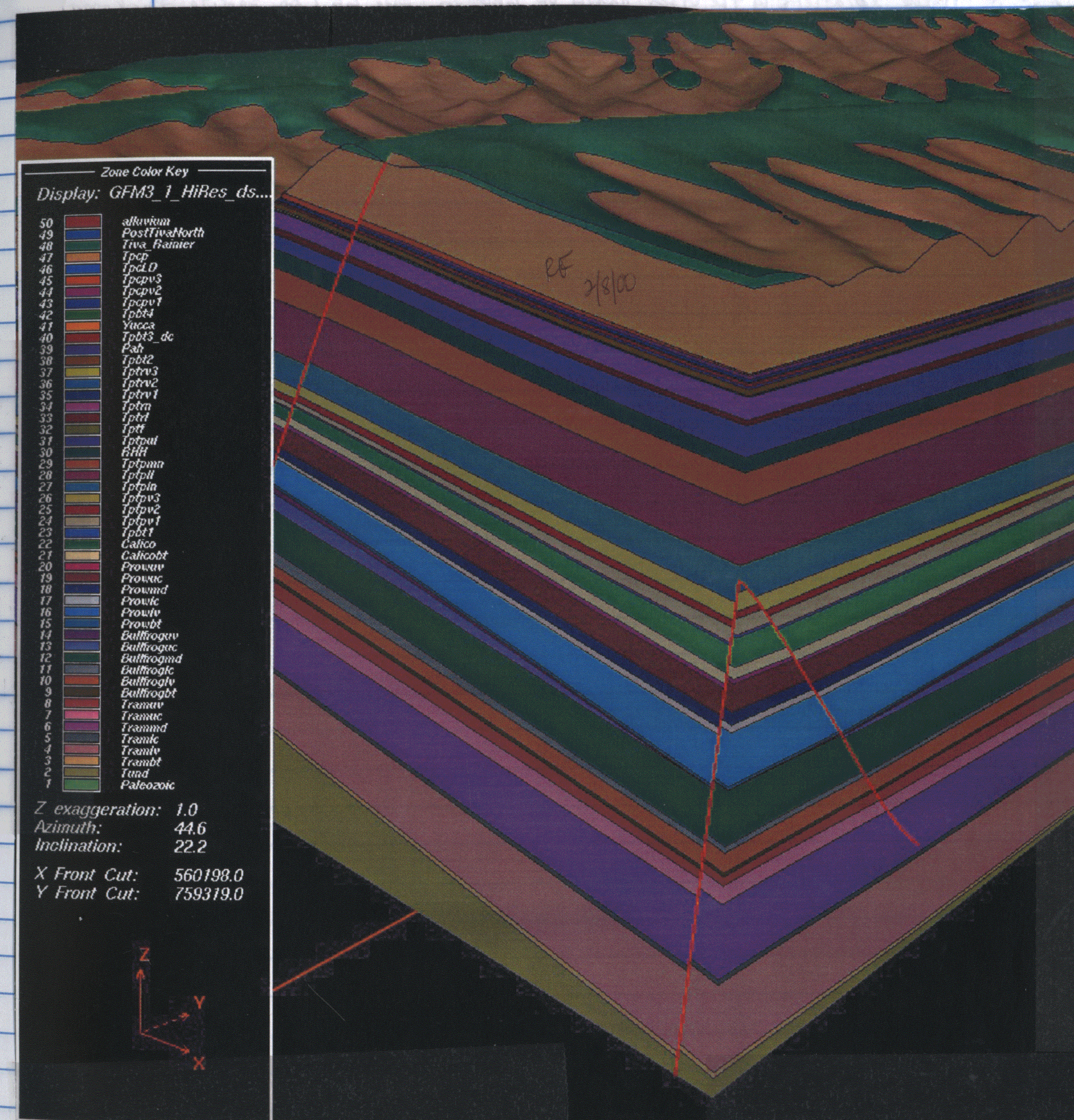
RF 2/27/00

relative to northern point of end of drift outline Northing 774160 (m) see page 61

Drift elevation calculated in spreadsheet elev = [0.00?0214 * Δy*] + 1045

RF 2/8/00

Problem noted with annotation file for center of SubArea 6. Sections of the column were repeated, thus reliability of thicknesses was checked by moving the cross-section west another 100 ft. This comparison is included in the table on page 65, as entry SA-66 (for SubArea 6). This figure below illustrates the problem with the fault (Abandoned Wash Fault?) cutting through the cross-section (SA-6.jpg)



RF 2/8/00

To estimate fraction of the CHn that are vitric and zeolitic, I used my interpolations from page 38 for subareas 1 to 7 (since minimum vitric thickness did not change for those subareas). Given the approx. method, and being on the conservative side, I use minimum vitric thickness found in a subarea. The values in the table on page 65 should match those minimum vitric thickness values from figures on page 38; the corresponding zeolite thickness for those minimum value locations is the other entry in table on page 65 (for zeolite thickness). The vitric fraction (vitric thickness / vitric + zeolitic thick) is then multiplied by the CHn total entry to get CHnv thickness & similarly CHnz entry

Filed: ~/zeolite/fits/cut4
brain: vit-invD.lay, zeol-invD.lay, repository-10.plt

RF 2/8/00

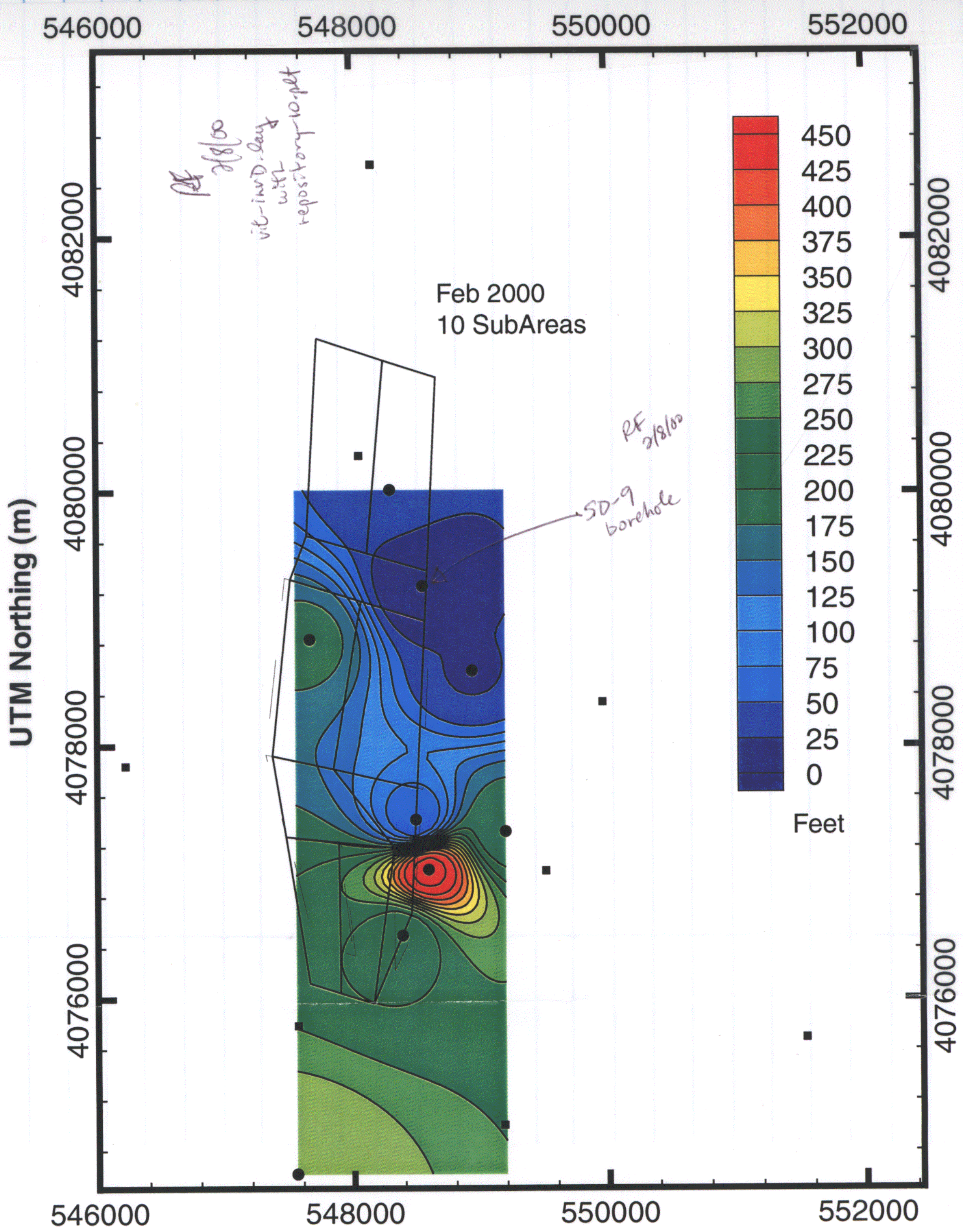


Figure 2. Interpolation of vitric horizon thickness in the unsaturated zone from 9 boreholes in the vicinity of the repository footprint. Solid circles mark the boreholes included in the interpolation whereas solid squares mark boreholes not included.

The figure on page 64 contains the interpolation from page 32, but the repository outline from TPA 4.0 ten subareas. Subareas 9 and 10 are not fully covered by the interpolation. However, since minimum vitric thicknesses are used, this is not an issue. Subareas 9 and 10 used the SE corner of each subarea as the point to estimate minimum vitric thickness and corresponding zeolite thickness. SubArea 8 used SD-9 borehole data since it is the minimum. The AMRs (Analysis Model Reports) on the ISM3.1 and Mineralogic Model (MM3.0) support the notion that there is the highest zeolitization at SD-9 and extending to the east (not the west)

"Integrated Site Model Process Model Report", Rev 00
TDR-NBS-GS-000002, Nov 1999
CRWMS M&O

"Mineralogic Model (MM3.0) Analysis Model Report, Rev00, MDL-NBS-GS000003, Nov 1999

SubArea Center Coordinates and Layer Thicknesses (meters)

	Coordinate Projection	SA-1	SA-2	SA-3	SA-4	SA-5	SA-6	SA-66	SA-7	SA-8	SA-9	SA-10
	UTM NAD27 Easting, m	559020.8	560813.9	559184.4	560937.4	559092.2	560197.5	shifted west of	561142.2	560273.6	559816.3	561353.5
	UTM NAD27 Northing, m	765676.4	765187.7	762417.1	762109.0	759526.2	759318.8	SA-6 center	759778.3	768248.2	771607.1	771122.6
	TPA 4.0 Layers											
	TSw	100	161	79	144	58	85		138	163	91	138
	CHnv	19	2	24	17	31	37		44	0	10	0
	CHnz	72	108	55	88	49	58		63	120	128	137
	Prow Pass welded	50	50	52	56	65	66		66	25	28	0
	Upper Crater Flat	57	18	68	61	71	81		67	0	9	0
	Bullfrog welded	22	0	81	0	101	51		0	0	0	0
RF 2/8/00	TOTAL	320	339	359	366	375	379		377	308	267	275
	TSw	100.5	161.1	79.1	143.8	57.5	85.0	95.2	137.5	162.9	91.1	137.5
	CHn Total	90.9	110.2	79.3	104.8	79.8	95.3	93.4	106.4	119.7	138.6	137.3
	Prow Pass welded	49.6	49.7	52.4	56.0	65.2	66.1	65.6	65.7	25.4	28.0	0.0
	Upper Crater Flat	57.1	17.8	68.2	61.2	71.2	81.1	79.5	67.0	0.0	9.0	0.0
	Bullfrog welded	21.8	0.0	80.6	0.0	100.9	51.0	44.8	0.0	0.0	0.0	0.0
	TOTAL	319.7	338.8	359.5	365.8	374.7	378.5	378.5	376.6	307.9	266.8	274.8
Elevation of Bottom of Stratigraphic Layer is Listed in Each Entry (feet)		(Thicknesses are calculated from contacts listed below) RF 2/8/00										
GFM 3.1 Stratigraphy	**TPA 4.0 Layers**	SA-1	SA-2	SA-3	SA-4	SA-5	SA-6	SA-66	SA-7	SA-8	SA-9	SA-10
	Drift Elevation	3545.8	3552.5	3590.8	3595.1	3630.8	3633.7	3633.7	3627.3	3510.2	3463.8	3470.5
Tptpv3	TSw	3216.2	3024	3331.4	3123.4	3442	3354.9	3321.3	3176.1	2975.9	3164.8	3019.3
Tptpv2,Tptpv1,Tpbt1	CHnv or CHnz	3163.3	2950.2	3260.3	3018.4	3346.9	3240.8	3211.5	3065.5	2922	3107.6	2940.5
Calico	CHnv or CHnz	3001.4	2746.8	3144.2	2851.3	3249.3	3114.8	3086.9	2898.9	2688.3	2831	2617.1
Thtbt (Calicobt), Tcp4(Prowuv)	CHnv or CHnz	2918.1	2662.3	3071.2	2779.6	3180.1	3042.1	3014.8	2827.1	2583.2	2710.2	2495.6
Prowuc, Prowmd, Prowlc	Prow Pass welded	2755.5	2499.2	2899.3	2595.9	2966.1	2825.1	2799.5	2611.6	2438.8	2618.2	2377.7
Prowlv, Prowbt, Bullfroguv	Upper Crater Flat	2568.1	2247.8	2675.7	2321.1	2732.5	2558.9	2538.8	2307.9	2165.5	2291.3	2016.1
Bullfroguc,Bullfrogmd,Bullfroglc	Bullfrog welded	2309.1	1765.8	2302	2000.8	2385.2	2264	2285.2	2037.6	1940.4	2140.5	1782.3
	Water Table (NRC Interpolation)	2496.7	2440.9	2411.4	2395.0	2401.6	2391.7	2391.7	2391.7	2500.0	2588.6	2568.9
	Drift elevation calculated (m)	1080.7	1082.8	1094.5	1095.8	1106.7	1107.5	1107.5	1105.6	1069.9	1055.8	1057.8
	Water Table approx (m)	761	744	735	730	732	729	729	729	762	789	783
		319.7	338.8	359.5	365.8	374.7	378.5	378.5	376.6	307.9	266.8	274.8
	Zeolitic Layer Thickness (ft)	315	424	315	373	308	308		300	432	412	432
	Minimum Vitric Layer Thickness (ft)	82	7	140	70	198	198		209	0	33	0.3
	Vitric Fraction	0.2065	0.0162	0.3077	0.1580	0.3913	0.3913		0.4106	0.0000	0.0742	0.0007

 2/9/00 RF Write-up for Sitakanta (bubo: D:\Randy\TPA\TPAcode\uzftchanges-section4.1.wpd) (and .\Zeolite\NewSubAreas Feb2000\thickness-table.wpd)

User Documentation Modification for UZFT Thicknesses for 10 Subareas in TPA 4.0
(RFedors, saved as file: G:\mohanty\4.0\uzftchanges-section4.1.wpd

RF 2/9/00

(add to section 4.6.3.1 after existing 1st paragraph, replace existing table 4-5 with the one below)
(table 4-5 entries translated to Appendix A)
(note also that references to TPA 3.2 can be changed to TPA 4.0)
(note also that modifications by RT folks [Dave Turner], if any, need to be incorporated)
(note also that Winterle dealt with the tpa.input hydrologic parameters changes for UZFT)

The thicknesses hydrostratigraphic layers (table 4-5) used in the UZFT module are derived from the Geologic Framework Model 3.1 (CRWMS M&O, 1999 [Integrated Site Model Process Model Report]) by aggregating thicknesses of thermal-mechanical stratigraphic layers of similar hydrologic properties. The thicknesses are taken from a representative location (i.e., center) in each subarea. Conversions are made from the UTM NAD27 (m) projection used for the subarea outlines in TPA 4.0 to the State Plane NAD27 (ft) projection used by the Geologic Framework Model 3.1. Calico Hills nonwelded vitric and nonwelded zeolitic thicknesses are estimated from the interpolation of thicknesses from borehole interpretations that consider zeolite percent and degree of welding (Winterle et al., 1999a,b [a = Review of the Unsaturated Zone Models Used to Support the Viability Assessment of a Repository at Yucca Mountain; b = Update of Hydrologic Parameters for the Total-System Performance Assessment Code]). The upper and lower boundaries of UZ transport are the drift elevations and the water table. The EDA II drift design (Oct 1999, preliminary) shows that the drift is horizontal in the east-west direction but slopes downward to the north 75 ~~m~~ ft; this slope is incorporated in the estimation of the thicknesses of the Topopah Springs welded layer. Based on borehole data, the water table elevation varies across the drift footprint by at least 45 m. The southeasterly slope of the water table is taken into account in the determination of the bottom layer thicknesses.

RF 4/29/04

Table 4.5 Stratigraphic thicknesses (m) for each of the ten repository subareas

Subareas	1	2	3	4	5	6	7	8	9	10
Topopah Springs, welded	100	161	79	144	58	85	138	163	91	138
Calico Hills, vitric	19	2	24	17	31	37	44	0	10	0
Calico Hills, zeolitic	72	108	55	88	49	58	63	120	128	137
Prow Pass, welded	50	50	52	56	65	66	66	25	28	0
Upper Crater Flat	57	18	68	61	71	81	67	0	9	0
Bullfrog, welded	22	0	81	0	101	51	0	0	0	0
TOTAL	320	339	359	366	375	379	377	308	267	275

2/9/00 RF

References

Civilian Radioactive Waste Management System Management and Operating Contractor. 1999. *Integrated Site Model Progress Model Report.* TDR-NBS-GS-000002, Rev 00. Las Vegas, NV: Civilian Radioactive Waste Management System Management and Operating Contractor.

Winterle, J.R., R.W. Fedors, D.L. Hughson, and S.A. Stothoff. 1999a. *Update of Hydrologic Parameters for the Total-System Performance Assessment Code.* CNWRA Letter Report. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

Winterle, J.R., R.W. Fedors, D.L. Hughson, and S. Stothoff. 1999b. *Review of the Unsaturated Zone Models Used to support the Viability Assessment of a Repository at Yucca Mountain.* CNWRA Letter Report. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

if needed:
Winterle, J.R., N.M. Coleman, W.A. Illman, and D. Hughson. 2000. *Review of Permeability Estimates Obtained from the Yucca Mountain Project.* CNWRA Letter Report. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses.

RF 2/9/00

 2/23/00

Niche/Alcove Figure   bubo: D:\AVData\Repository\

D. Hughson needed a figure for her niche report (deliverable IM 1402.861.010). This was done in ArcView 3.1

EDA II design for repository & drift & ESF outline, (see page 58, Sci NtbK #294) plus major faults, plus all of the niches and alcoves overlayed onto a figure. Fault traces (surface, ground) are from Day et al. 1998 Central Block map

Niche and Alcove locations   UTM NAD27 (m)

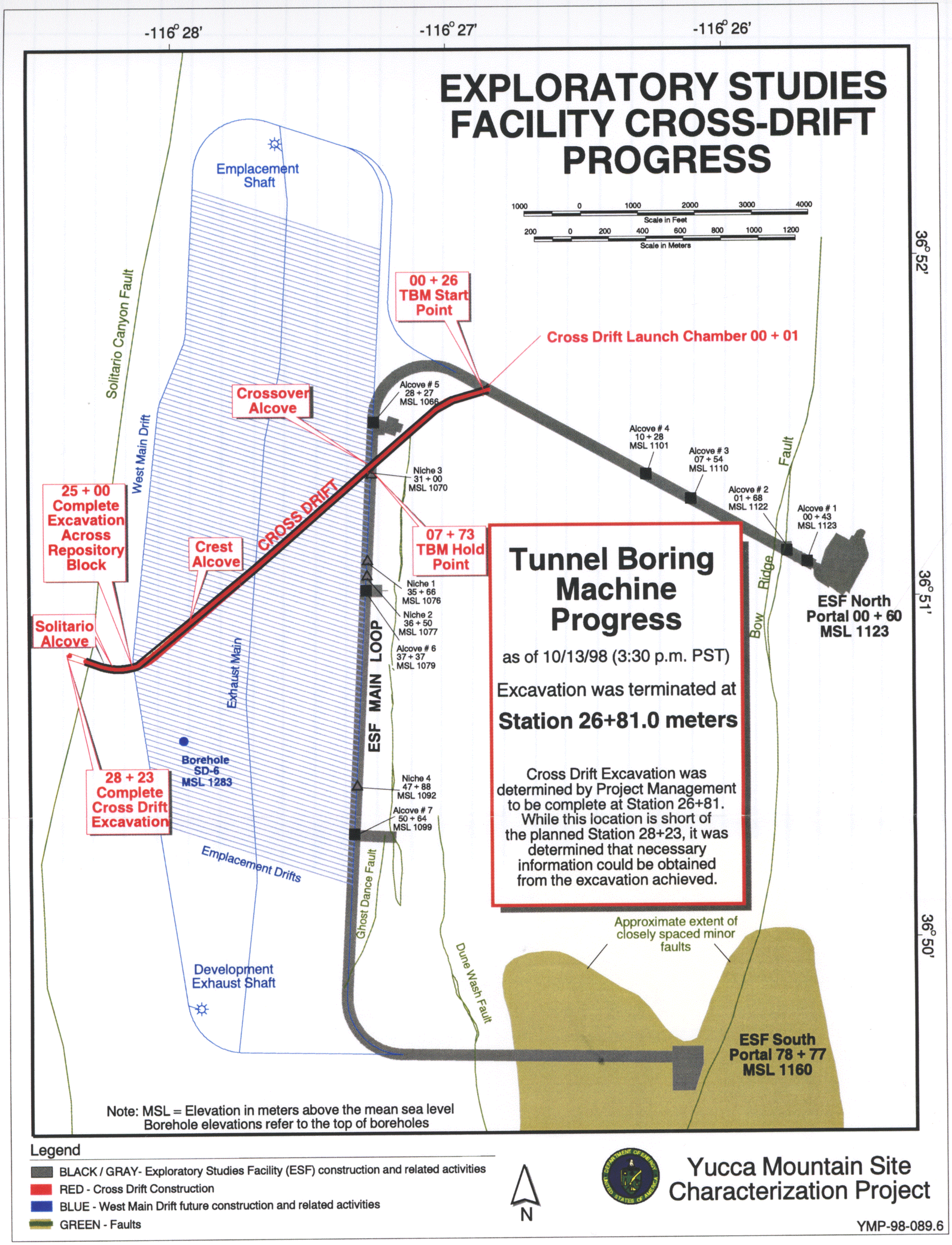
		Easting	Northing	
from YMP Progress Report see page 69	Alcove 1	550952	4078480	Estimated by measuring
	Alcove 2	550843	4078539	distance from north portal
	Alcove 4	550089	4078953	
	Alcove 3	550329	4078821	From Grid Generation AMR
	Alcove 5	548682	4079216	page 35
	Alcove 6	548666	4078327	
	Alcove 7	548611	4077002	I assumed that northing location
	Niche 3566	548584	4078498	was correct for Alcoves 5, 6, 7;
	Niche 3650	548580	4078414	see note below on error in
	Niche 4788	548525	4077277	DOE report. The possible error
	Niche 3107	548607	4078956	is not significant in regards to this figure

Development of Numerical Grids for UZ Flow and Transport Modeling (U0000)
ANL-NBS-HS-000015 Rev 00 Sept 1999
Analysis Model Report (AMR, I think that's what it stands for)

Alcoves 5,6,7 did not fall on ESF
Alcove 5 ⇒ ~60 m east of ESF
Alcove 6 ⇒ ~90 m east of ESF
Alcove 7 ⇒ ~100 m east of ESF

In the AMR, page 35, the footnote states that a spreadsheet was used to calculate the UTM locations from the distance from north portal.

Files: repository-niche.apr : ArcView 3.1
fig-1.ai & fig-1-mod.ai : Adobe Illustrator 8. (see page 70)



Locations of some alcoves, relative to North Portal

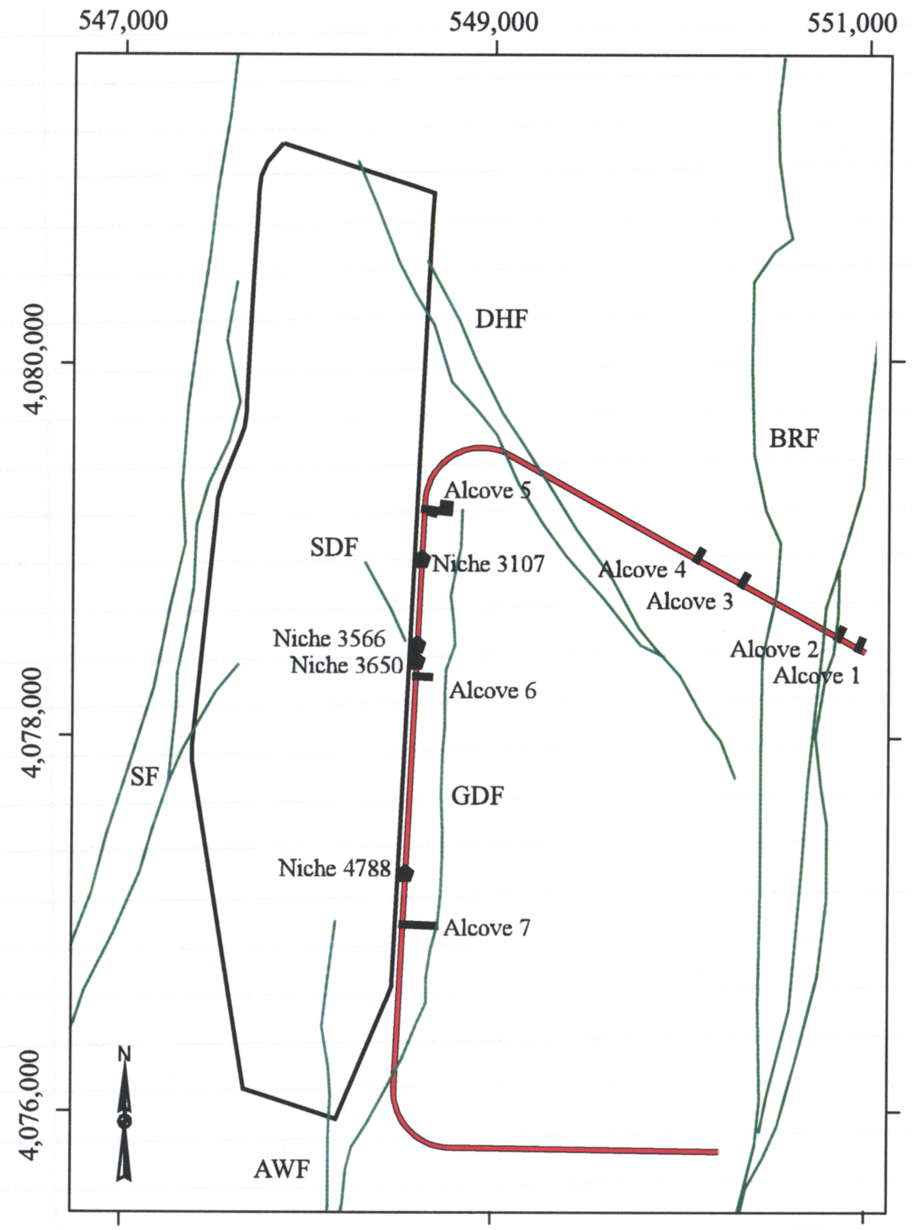
RF 7/23/00

RF 7/23/00

69

RF 3/23/00

Figure 1 for Niche Report (Hughson et al.)
(fig-1-mod.ai)



RF 3/23/00

Figure 1. Niche and alcove locations along Exploratory Studies Facility (ESF). West of the ESF, the outline of drift area is shown. Surface traces of large faults in the vicinity of the drift area and ESF are also shown; Ghost Dance Fault (GDF), Solitario Canyon Fault (SF), Bow Ridge Fault (BRF), Drill Hole Wash Fault (DHF), Sundance Fault (SDF), and the Abandoned Wash Fault (AWF). The coordinates are in UTM NAD27 (m).

RF 3/8/00

Niche & Alcove figure, except instead of ground surface traces of faults, use repository horizon trace of faults

GFM 3.1, faces file using EarthVision 5
[pluto: /data2/models/gfm31/MO9901MWDGFM31.000/
./GFM3-1_HiRes_unsliced.faces]

Slice the the faces file using elevation 1100 m (3609 ft msl) and:

774,243
556,500 | 569,854 easting & northing bounds
756,639

RF 3/25/00

then re-orient the view to plan view & save raster image.

Bring this raster into Illustrator 8 and scale to fit into view of Fig-1-mod.ai to visually see the shift in faults between ground surface & repository horizon. Transparency mode of this figure and new fault locations digitized in ArcView 3.1

bubo: d:\AVData\Repository\repository-niche-faults.apr
faults-repos shape files

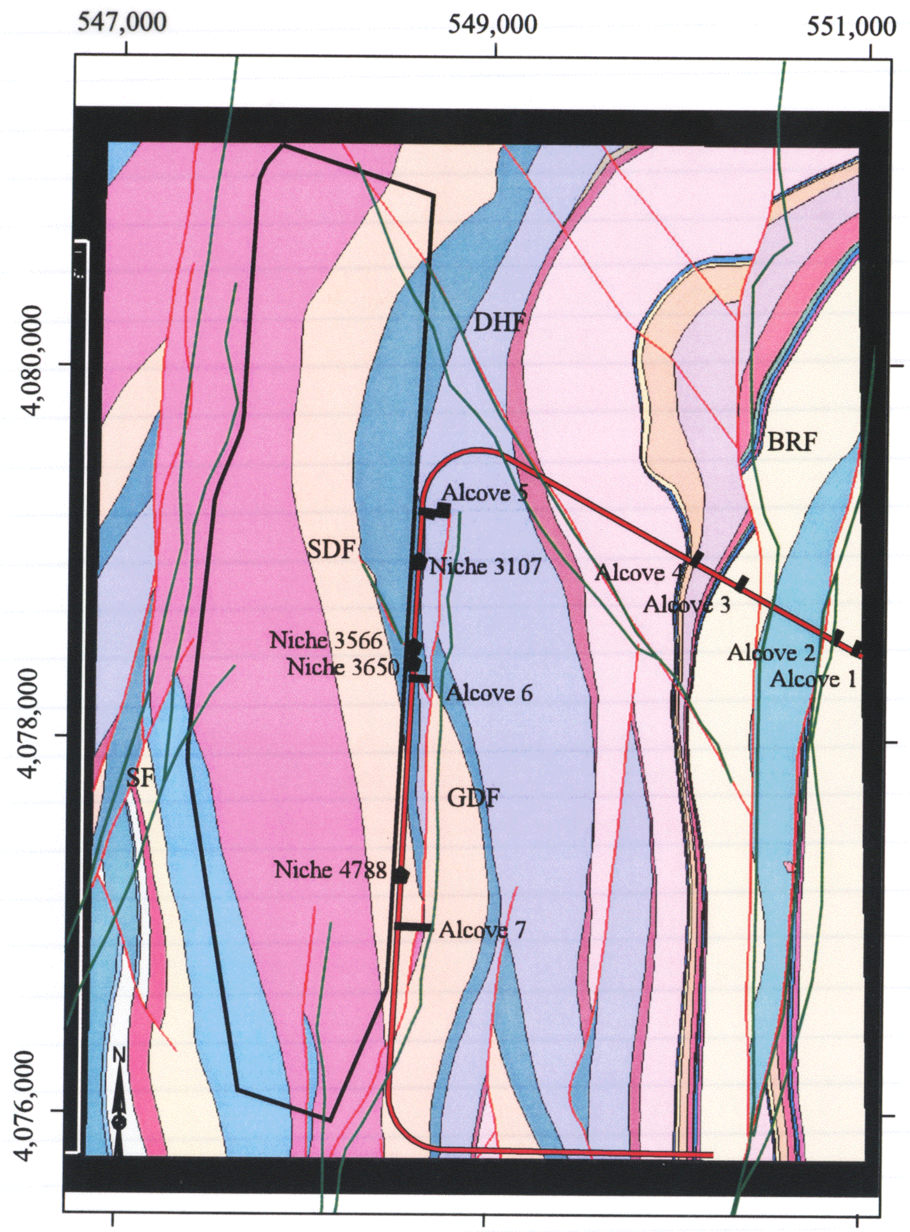
Now this figure is exported as a postscript from ArcView and brought into Illustrator

The figure with the raster geology map underlay on Figure 1 is on page 72

The new figure with fault traces at the repository horizon is on page 73. (fig-niche-porosity.ai)

RF 3/8/00

EarthVision slice of geology at Repository horizon (1100 m msl)



RF 3/8/00

Figure 1. Niche and alcove locations along Exploratory Studies Facility (ESF). West of the ESF, the outline of drift area is shown. Surface traces of large faults in the vicinity of the drift area and ESF are also shown; Ghost Dance Fault (GDF), Solitario Canyon Fault (SF), Bow Ridge Fault (BRF), Drill Hole Wash Fault (DHF), Sundance Fault (SDF), and the Abandoned Wash Fault (AWF). The coordinates are in UTM NAD27 (m).

RF 3/8/00

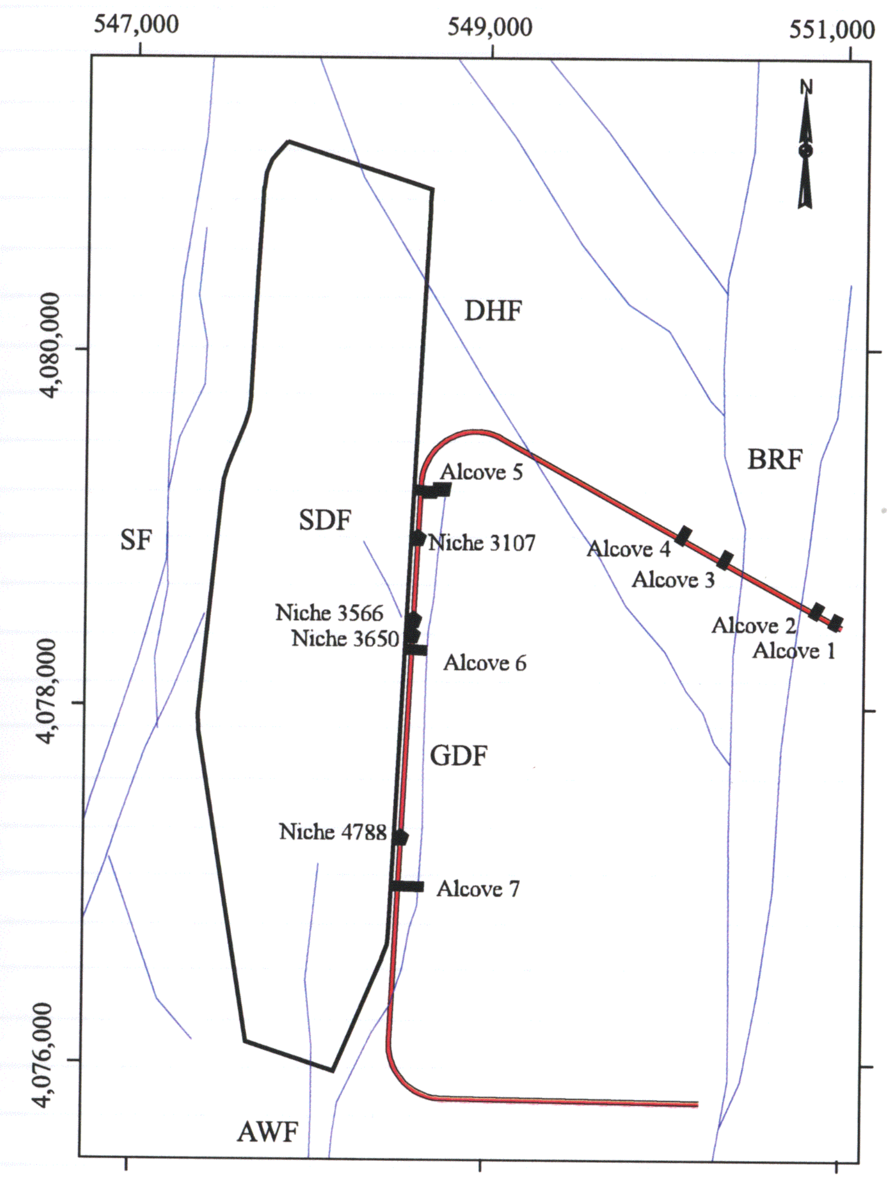


Figure 1. Niche and alcove locations along Exploratory Studies Facility (ESF). West of the ESF, the outline of drift area is shown. Traces of large faults in the vicinity of the drift area and ESF at the repository horizon (1100 m msl) are also shown; Ghost Dance Fault (GDF), Solitario Canyon Fault (SF), Bow Ridge Fault (BRF), Drill Hole Wash Fault (DHF), Sundance Fault (SDF), and the Abandoned Wash Fault (AWF). The coordinates are in UTM NAD27 (m).

 3/14/00 RF

ECRB Added to Arc View

bubo: D:\AVData\Repository\ecrb.shp files

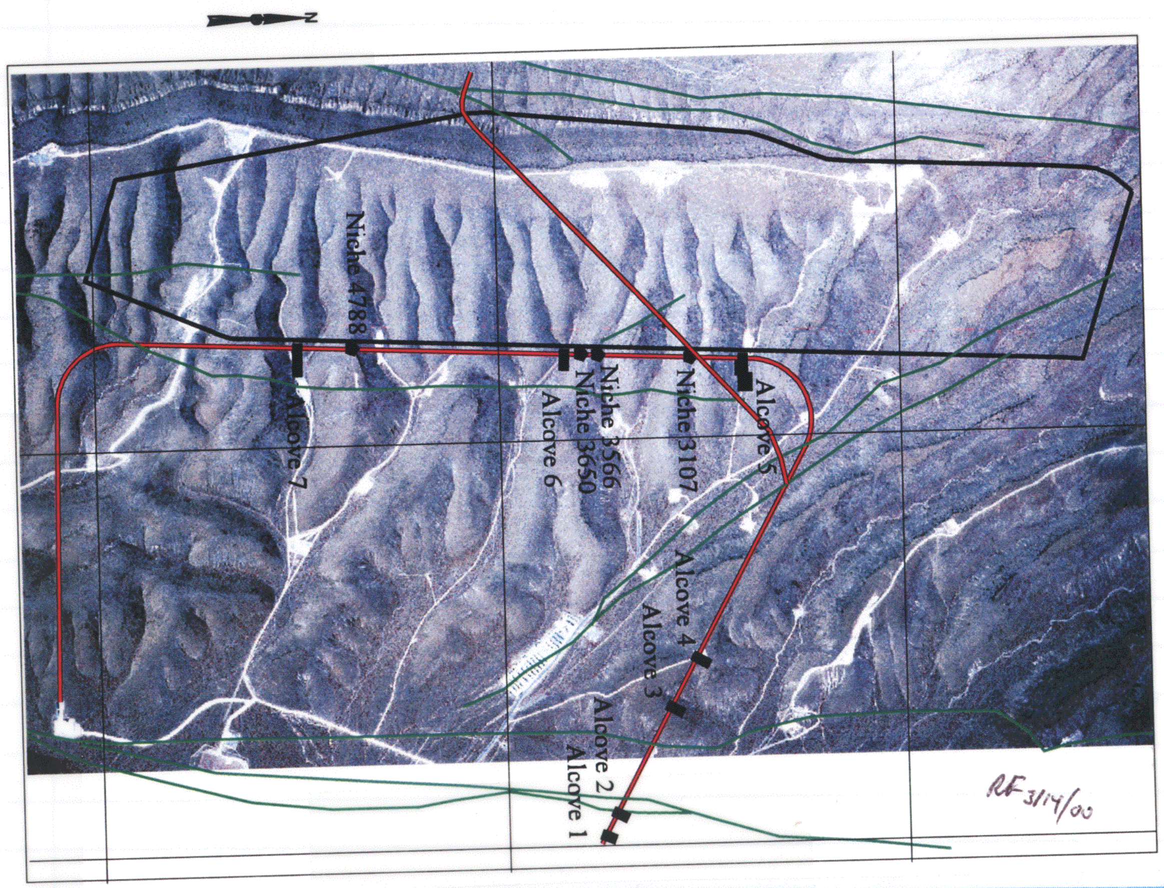
From characterization Progress Report #20, YM, Nevada
Nuclear Waste Policy Act (section 113)
Oct 1, 1998 – March 30, 1999 Number 20, October 1999
DOE Office of Civilian Radioactive Waste Management

See page 85
DOE-supplied ECRB coordinates (GIS file)
RF 6/21/00
J:\AVData\Repository\DOE_ecrb*

Figure 1 page 1-3 — UTM NAD27 (m)
ECRB starts at ESF 19+92 ⇒ 549244.0, 4079417.3
and is completed length = 2681 m

Cross-over point ECRB & ESF ⇒ ESF 30+62 → 548608.6, 4078995.2

Complete Cross Drift Excavation = 26+81
Edge of repository block at = 25+00



RF 3/14/00

RF 4/28/00

PTn Modeling – Modeling & Constitutive Relations for Goodluck **4/28/00**

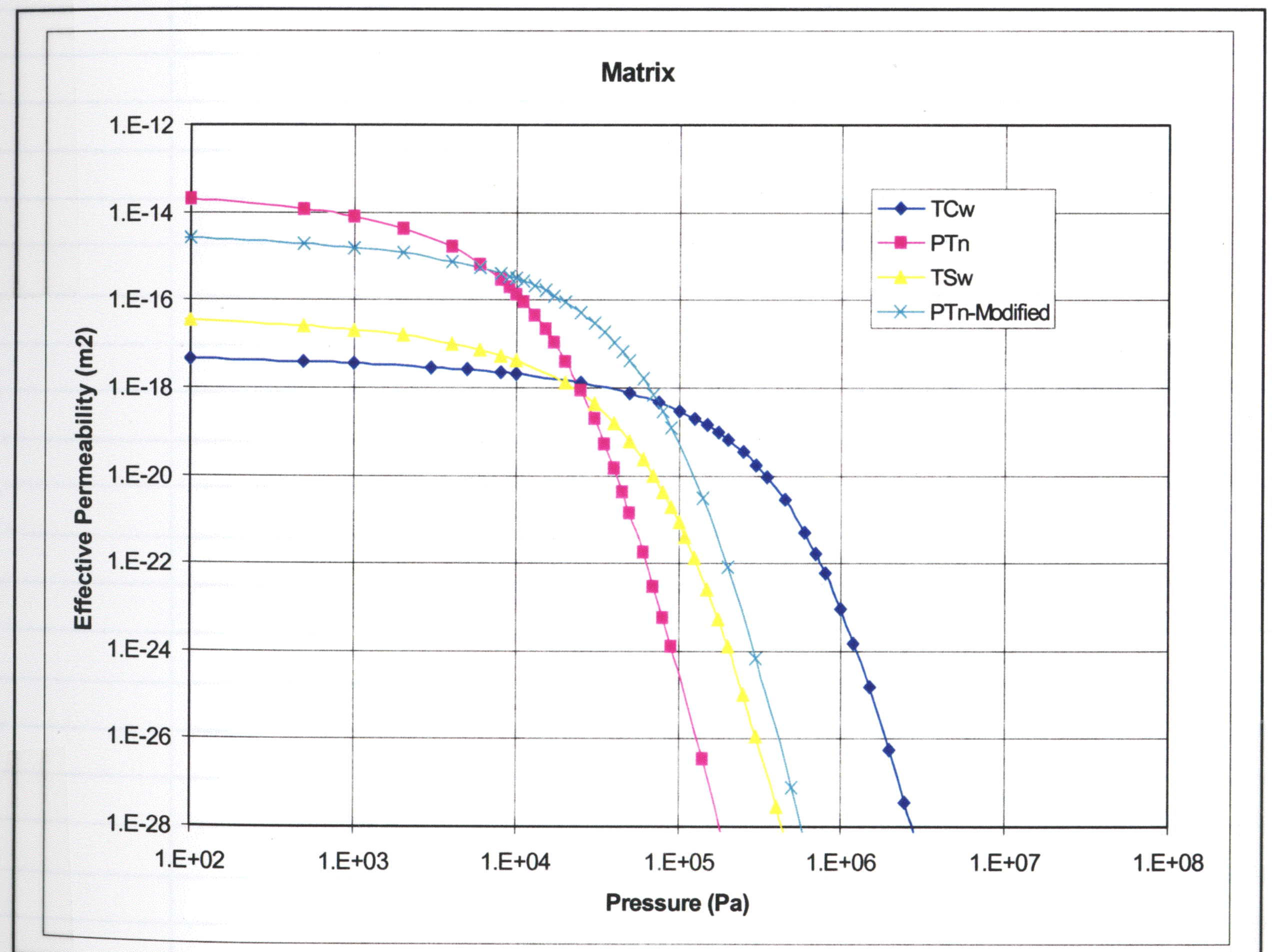
RF 4/28/00

All work was done on bubo (Ntbox) using Excel 97 SR-2, WordPerfect 8.0.

Goodluck has been modeling a site-scale UZ 2D cross-section (east-west) for the past year. I have been helping him develop the section from EarthVision and GFM 3.1 and determine the hydrologic parameters to use in the model. More recently I have been helping him evaluate the simulation results and modify matrix properties associated with small faults and slumps in the PTn deformation. The latter effort was done in connection with possible fast pathways through the PTn and was precipitated by my discussions of Cl-36 data.

Modifying the matrix properties of the PTn to reflect grain crushing and/or re-organization in finite volume cells representing matrix adjacent to faults should result in a focusing of flow through the matrix. This is expected because the capillary effect of a finer-grained material, and the greater effective permeability of the fault associated matrix block. See the figures below (from J:\HydroProperties\PtnFault\barriers.xls, the vanGen spreadsheet).

Also note in the figure this page that the modified PTn (modified to reflect grain crushing and/or grain re-organization) has a much larger effective conductivity at tensions reflective of YM (~1 bar = 100 kPa). The permeability was decreased by 1 order of magnitude and the van Genuchten α was increased to 1E-5 Pa^{-1} as compared to the table listing for PTn on the following page (76). The effective permeability is almost 3 orders of magnitude larger for the modified PTn. This is where flow in Goodluck's model is getting through the PTn. His modifications of the fracture continuum hydrologic properties are expected to have little effect on flow enhancement through the PTn.



RF 4/28/00

Base Case UZ Sit-Scale Parameter Values (Tech Basis, B00000000-01717-4301-00002 Rev 01, 1998)
Matrix Values

tcw12	ptn21	tsw31	ptn21-mod	
TCw	PTn	TSw		
0.13	0.1	1.00E-05	0.1	residual saturation
0.066	0.369	0.042	0.369	saturated water content
1.32E-06	3.80E-05	1.00E-05	1.00E-05	alpha (Pa-1) --->
1.3089	1.3004	1.3106	1.3004	beta, METRA m
0.236	0.231	0.237	0.231	gamma, METRA λ
5.37E-18	3.90E-14	4.90E-17	3.90E-15	k (m2)

RF 4/28/00

For constitutive relations used in spreadsheet, see van Genuchten (1980) A Closed-Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils, Soil Science Society of America Journal, vol 44, p 892-898.

Also, there were disagreements about lateral flow at the top of the PTn and at the bottom of the PTn. I thought there was too much lateral flow in and at the top of the PTn in the model results as compared with field observations where no evidence has been found for lateral flow, except at the locally welded horizons within the middle of the PTn. Scott Painter indicated that these were classic capillary barriers at both locations; he's right if you consider TCw matrix flow into PTn matrix, and also PTn matrix into TSw fractures. Note that flow is dominantly fracture flow in the TCw and TSw and dominantly matrix flow in the PTn. However, conceptually, TCw fracture flow to PTn matrix flow is a permeability barrier. And PTn matrix to TSw fracture flow is conceptually a capillary barrier. However, Multiflo does not have connections between the fracture continuum and the overlying matrix continuum. Flow in Goodluck's steady state model must go from the PTn matrix to the TSw matrix and then into the TSw fractures. Hence, the matrix interaction term in the TSw horizon is dictating the "capillary barrier." The finer pores of the TSw would over-emphasize the capillary barrier into the fracture continuum as compared to the coarser pores of the PTn. There is also some question of whether Multiflo can actually model a capillary barrier using the matrix/fracture interaction formulation. Discussions of capillary barriers will be left out of Goodluck's report.

Also note in the figure on page 75 that the modified PTn (modified to reflect grain crushing and/or grain re-organization) has a much larger effective conductivity at tensions reflective of YM (~1 bar = 100 kPa). The effective permeability is almost 3 orders of magnitude larger for the modified PTn. This is where flow in Goodluck's model is getting through the PTn. His modifications of the fracture continuum hydrologic properties are expected to have little effect on flow enhancement through the PTn.

The following was given to Goodluck for his TEF report:

II.D Hydrologic Properties of a Generic Minor Fault

Given the hydraulic properties of the TCw, PTn, and TSw, lateral flow along the bedding planes would be expected to occur. The evidence, however, suggests that the lateral downslope flow of water associated with the shallow sloping nonwelded beds is limited to tens of meters before vertical breakthrough (CRWMS M&O, 1997). No perched water has been found, nor has any evidence of springs been found at exposed PTn bedding contacts. Numerous hypotheses have been suggested for the lack of significant lateral flow and ponding. Flow through fractures in the PTn does not appear to explain this evidence because matrix sorption of water flowing in fractures is strong in the PTn based on estimated hydraulic properties of the matrix and fractures (Flint et al., 1996). Flow vertically through faults likely occurs but this does not explain the lack of continuity of lateral flow since mapped faults are widely spaced (100s to 1000s of meters) in the YM block. Laterally, the PTn is a relatively uniform pyroclastic series of deposits with some local evidence of slight reworking (Moyer et al. 1996). Primary lateral variations in the uniform tuffs generally change over large distances and thus also cannot explain the lack of continuity of lateral flow.

Secondary features, such as an overprint of deformation caused by fracturing or small-scale faulting, offer a possible explanation for the periodicity of breakthrough of flow through the PTn. The hypothesis presented here is that small faults, potentially spaced on the order of tens of meters or less, may induce local changes in matrix properties that

RF 4/28/00

induce vertical flow. Small faults are not generally mapped and many times are not readily visible at a macroscopic scale in cores or poorly exposed area.

Changes to Bedrock Properties in Fault Zones

RF 4/28/00

To model the effect of a small fault crossing the PTn, the hydrologic parameters of permeability, van Genuchten α and m, and porosity are needed. Based on sensitivity analyses, the most important are the permeability and the van Genuchten α parameters. To bound estimates for these parameters adjacent to small faults, published work on measurements in poorly-lithified sediments will be used.

There is generally a narrow fault core or gouge and a broad damage zone surrounding faults. The type of deformation in the damage zone and the fault core vary with burial depth and rock type. The structure of faults in crystalline have been discussed in special publications (McCaffrey et al., 1999; Jones et al., 1998) and by Caine and Forster (1999) and Evans et al. (1997). Heynekamp et al. (1999) and Fisher and Knipe (1999) discussed the features of fault zones in lithified and poorly-lithified sediments. The focus here will be on poorly-lithified sediments cut by faults since they more clearly reflect the behavior expected for the nonwelded tuffs at YM. The change in hydrologic properties near fractures or small faults in the nonwelded tuffs at YM have not been directly studied.

Five types of mechanisms for grain size reduction were noted by Fisher and Knipe (1999): (i) deformation induced mixing of clays with framework grains, (ii) pressure solution, (iii) cataclasis, (iv) clay smear, and (v) cementation. As an analog for small-scale faults cutting the nonwelded pyroclastic tuffs at YM, textural changes to poorly-lithified sediments in damage zones surrounding faults and in the cores of faults is likely limited to grain-size reduction, repacking, and reorientation . These changes will lead to reductions in porosity, permeability, and van Genuchten a parameter; the latter parameter is negatively correlated with the air-entry pressure. There is no evidence for cementation or pressure solution modifications except possibly at the major fault zones (Moyer et al., 1996).

The permeability reductions caused by oriented slip surfaces or grain size reduction both lead to permeability reductions perpendicular to the fault slip plane. For saturated flow, this reduction may lead to the fault becoming a barrier to flow. In the unsaturated zone, the flow behavior is more complex. The grain size reduction may lead to a higher conductance because the finer pore size may lead to higher effective permeability at low unsaturated flux rates. At higher unsaturated flux rates, the grain size reduction may lead to a permeability barrier. For the sloping YM nonwelded tuffs, the permeability barrier created by the grain size reduction in a damage zone would cause water flowing laterally along bedding planes to flow vertically. The discontinuous slip surfaces oriented parallel to the fault plane may lead to permeability anisotropy, though the slip surfaces may otherwise have little effect on unsaturated flow.

Fisher and Knipe (1999) noted permeability reduction of 3 to 4 magnitudes for faults with discrete slip bands and reductions of non to 2 orders of magnitude for homogeneous faults. The abundance of clays in the fault zones can be important. Heynekamp et al. (1999) emphasized the effect of the primary clay fraction on the reduction in the interlayered sands and clay-bearing sediments. Layers with abundant clay may exhibit a repacking that can led to a permeability reduction. Smearing of clay lenses can also lead to reductions in permeability.

In sandstones at Moab, Utah, Antonellini and Aydin (1994) measured large permeability and porosity reduction in deformation bands, zones of deformation bands, and slip planes associated with faults. They noted that the intensity of cataclasis and the clay content of the host rock control the magnitude of the permeability reduction. For deformation bands, porosity reduction of one order of magnitude and permeability reductions of three orders of magnitude relative to the host rock were measured (table 34).

At two sites in the Rio Grande Rift basin in New Mexico, Sigda et al. (1999) measured hydraulic properties in the field and laboratory parallel and perpendicular to small faults (table 34). The small faults at one site contained no fault core or gouge zone while the small faults at the other site did contain a narrow fault gouge. At both sites in the study, the fault zone exhibited a wide range of permeability values while the undeformed areas exhibited a narrow range. Sigda et al. (1999) noted the bi-modal distribution of measured permeabilities in the damaged or mixed zones. They conjectured that the low population was associated with areas with grain size reduction and the high-permeability population was associated with pods of less deformed sediments. They also measured increases in clay fraction and sharp decreases in macroporosity in the fault zones.

RF 4/28/00

Table 34. Tabulated values of reductions in permeability and porosity in deformation zones of faults cutting poorly-lithified sediments.

	Permeability Host Rock	Permeability Damage Zone	Porosity Host Rock	Porosity Damage Zone
Sandstone, Moab, UT [1]	0.6 - 5 d	0.002 - 0.01 d	0.17 - 0.22	0.01 - 0.05
Sandstone, Santa Ana [2]	3 - 46 d	01. - 7 d	0.28	0.16 - 0.24
Sandstone, Elmendorf [2]	4 - 12 d	0.2 - 8 d	0.25	0.17

[1] Antonellini and Aydin (1995)
[2] Sigda et al. (1999)

An alternative approach for evaluating the effect of small faults on hydrologic properties is to postulate a change in grain size distribution caused by the small fault and classify that change in terms of a grain sized-based soil classification system. Hydrologic property values for members of the soil classification system are published by Carsel and Parrish (1988). The advantage in this approach is that there would be consistency in the changes of permeability and van Genuchten α, which are strongly correlated parameters for many soils and rocks. In sandstones at Moab, Utah, Antonellini and Aydin (1994) measured pore-throat size reductions of at 1 order of magnitude using image analysis. A reduction in pore size should lead to a decrease in both the permeability and the van Genuchten α unsaturated zone parameter. It is difficult to estimate the magnitude of these changes although a shift in soil class from loamy sand to clay loam might be comparable. The van Genuchten α would decrease by 6 and the permeability by 1.5 orders of magnitude from the loamy sand to the finer-grained clay loam based on typical parameter values reported in Carsel and Parrish (1988) and listed in table 35. Sigda et al. (1999) measured reductions in macroporosity and increases in microporsity, which are consistent with a shift in soil class from a loamy sand to clay loam.

Table 35. Unsaturated zone parameter values for 2 soil types reflecting possible differences caused by grain size reduction in deformation zones of a fault

	K_{sat} (cm/hr)	van Gen. α (cm^{-1})	van Gen. λ	van Gen. m
Loamy Sand	14.6	0.124	0.56	2.28
Clay Loam	0.26	0.019	0.24	1.31

In summary, changes to matrix hydrologic properties caused by secondary feature such as a small fault have not been measured at YM but may be bounded by values published for poorly-lithified sediments found elsewhere. The unsaturated zone parameters have not been published, likely because fault properties are of high interest in the oil industry and not for the near-surface unsaturated zone. The unsaturated zone parameter values used here are entirely conjectural. The use of sandstones may lead to an underestimate because the PTn at YM contain abundant clays that would lead to greater reductions in permeability.

RF 4/28/00

RF 4/28/00

References

Antonellini, M. and A. Aydin 1994. Effect of Faulting on Fluid Flow in Porous Sandstones: Petrophyical Properties; AAPG Bulletin 78(3), pp. 355-377.

Antonellini and Aydin 1995. Effect of Faulting on Fluid Flow in Porous Sandstones: Geometry and Spatial Distribution; AAPG Bulletin 79(5), pp. 642-671.

Carsel R.F. and R.S. Parrish, 1988. Developing Joint Probability Distributions of Soil Water Retention Characteristics; Water Resources Research, Vol. 24(5), pp. 755-769.

CRWMS M&O, 1997. Unsaturated Zone Flow Model Expert Elicitation Project, CRWMS M&O MOL.19971009.0582, Las Vegas, NV: Civilian Radioactive Waste Management System Management and Operating Contractor.

Evans, J.P., C.B. Forster, and J.V. Goddard 1997. Permeability of Fault-Related Rocks, and Implications for Hydraulic Structure of Fault Zones, Journal of Structural Geology 19(11), pp. 1393-1404.

Fisher, Q.J. and R.J. Knipe, 1999. Fault Sealing Processes in Siliciclastic Sediments; in Faulting, Fault Sealing and Fluid Flow in Hydrocarbon Reservoirs, eds. G. Jones, Q.J. Fisher, and R.J.Knipe, Geological Society Special Publication No. 147, London: The Geological Society, pp.117-135.

Flint, L.E., A.L. Flint, C.A. Rautman, and J.D. Istok, 1996. Physical and Hydrologic Properties of Rock Outcrop Samples at Yucca Mountain, Nevada, USGS Open-File Report 95-280, Denver, CO: U.S. Geological Survey.

Heynekamp, M.R., L.B. Goodwin, P.S. Mozley, and W.C. Haneberg, 1999. Controls on Fault-Zone Architecture in Poorly Lithified Sediments, Rio Grande Rift, New Mexico: Implications for Fault-Zone Permeability and Fluid Flow; in Faults and Subsurface Fluid Flow in the Shallow Crust, eds. W.C. Haneberg et al., Geophysical Monograph 113, Washington, DC: American Geophysical Union, pp. 27-50.

Jones, G., Q.J. Fisher, and R.J. Knipe, eds., 1998. Faulting, Fault Sealing and Fluid Flow in Hydrocarbon Reservoirs, Geological Society Special Publication No. 147, London: The Geological Society

McCaffrey, L. Lonergan, and J.J. Wilkinson, eds., 1999. Fractures, Fluid Flow and Mineralization, Geological Society Special Publication No. 155, London: The Geological Society.

Moyer, T.C., J.K. Geslin, and L.E. Flint, 1996. Stratigraphic Relations and Hydrologic Properties of the Paintbrush Tuff Nonwelded (PTn) Hydrologic Unit, Yucca Mountain, Nevada, USGS Open-File Report 95-397, Denver, CO: U.S. Geological Survey.

Sigda, J.M., L.B. Goodwin, P.S. Mozley, J.L. Wilson, 1999. Permeability Alteration in Small-Displacement Faults in Poorly Lithified Sediments: Rio Grande Rift, Central New Mexico; in Faults and Subsurface Fluid Flow in the Shallow Crust, eds. W.C. Haneberg et al., Geophysical Monograph 113, Washington, DC: American Geophysical Union, pp. 51-68.

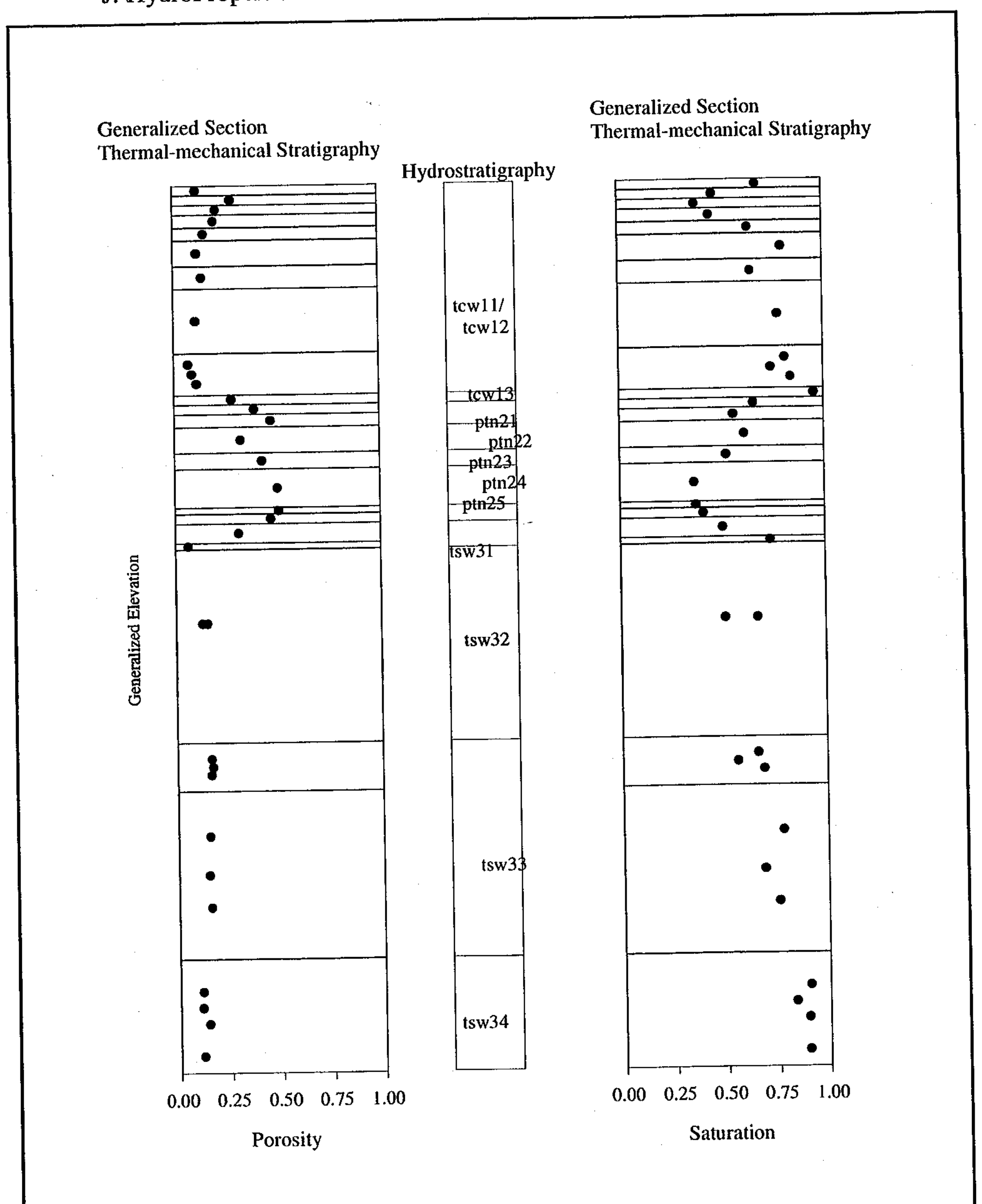
PTn Modeling – Water Contents & Constitutive Relations for Walter **4/28/00**

All work was done on bubo (Ntbox) using Excel 97 SR-2, WordPerfect 8.0, SigmaPlot 5.0.

The plan for Walter's modeling of the PTn is to include heterogeneity of shallow infiltration input (both spatially and temporally) and heterogeneity of PTn matrix properties. He is developing a 2D dual continuum model of the lower TCw, the PTn, and the upper TSw at a fine scale (~3m grids). His first task is to incorporate the shallow infiltration heterogeneity; later he will add matrix heterogenity that will include both primary heterogeneity and secondary modifications to the PTn (e.g, alteration, or Goodluck's fault/slump associated changes).

Since Walter is doing a "representative" section, I generated a generalized saturation profile for him to calibrate to. I used Lorrie Flint's spreadsheet (generated for Flint, 1998, Characterization of Hydrogeologic Units Using Matrix Properties, Yucca Mountain, Nevada, USGS Water-Resources Investigations Report 97-4243). The Flint data was sorted and hydrostratigraphic unit values of saturation were obtained by arithematic averaging of all measured core samples. The spreadsheet is

J:\HydroProperties\WaterContent\PtnModeling_flintLori.xls generalized water contents from Flint data
J:\HydroProperties\WaterContent \FlintGeneralized.JNB SigmaPlot file



PtnModeling_flintLori.xls

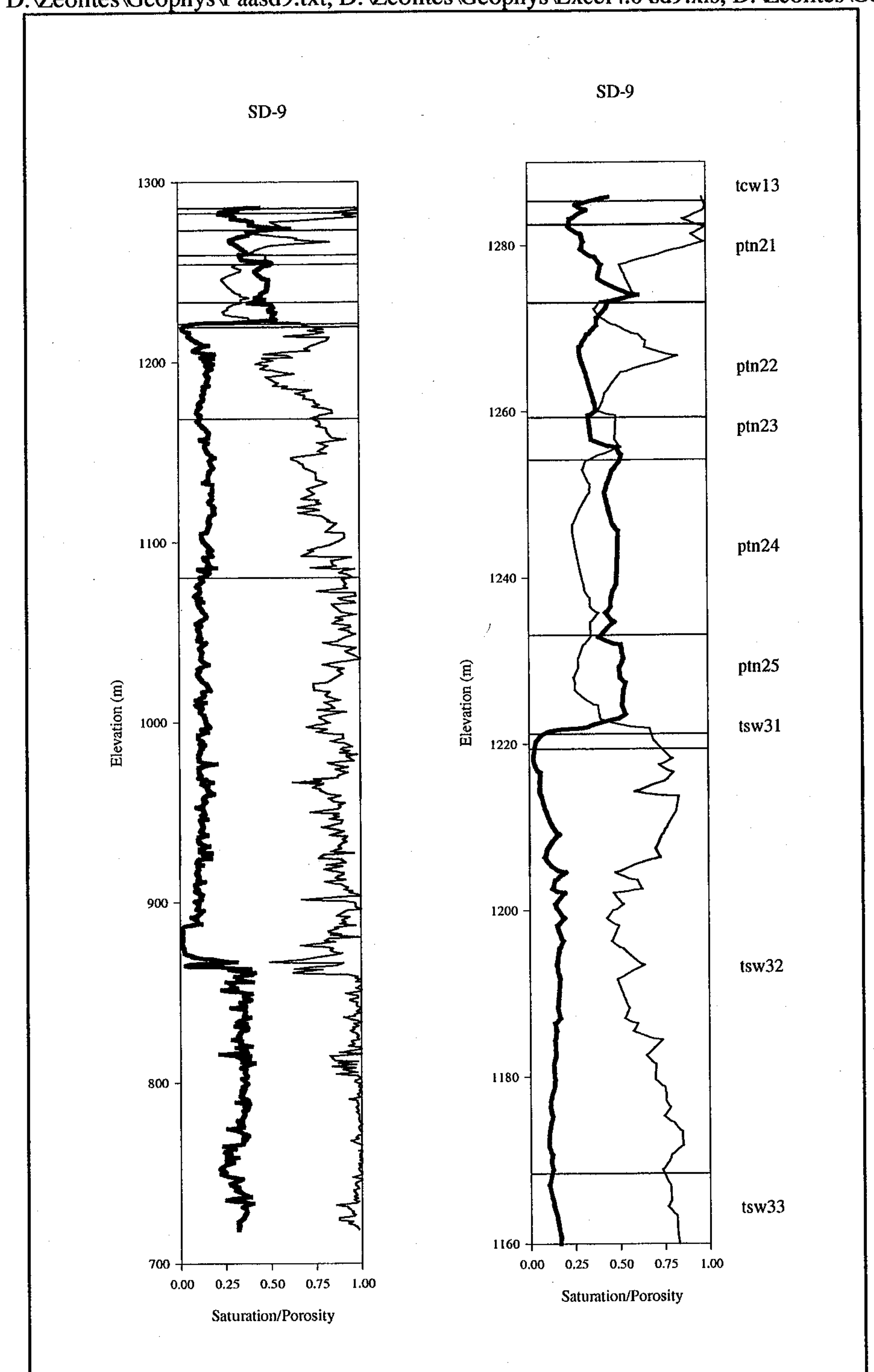
	Thermal-Mechanical Stratigraphy				Hydrostratigraphy			Flint 1998 Hydrostratigraphy	
	Porosity	VWC	Saturation		Porosity	VWC	Saturation		Porosity
Tpcrn4	0.112	0.072	0.676	tcw11/tsw12	0.120	0.079	0.732	CCR	0.112
Tpcrn3	0.283	0.129	0.462	tcw11/tsw12				CUC	0.232
Tpcrn2	0.210	0.071	0.376	tcw11/tsw12				CUC	
Tpcrn1	0.198	0.076	0.446	tcw11/tsw12				CUC	
Tpcrl2	0.148	0.093	0.634	tcw11/tsw12				CUC	
Tpcrl1	0.114	0.089	0.796	tcw11/tsw12				CUC	
Tpcul	0.137	0.087	0.646	tcw11/tsw12				CUL	0.137
Tpcmn	0.107	0.082	0.777	tcw11/tsw12				CW	0.082
Tpcll	0.088	0.064	0.742	tcw11/tsw12				CW	
Tpclnh	0.070	0.056	0.810	tcw11/tsw12				CW	
Tpclnc	0.110	0.091	0.840	tcw11/tsw12				CMW	0.110
Tpcpv2	0.278	0.259	0.950	tcw13	0.278	0.259	0.950	CNW	0.342
Tpcpv1	0.388	0.243	0.654	ptn21	0.405	0.244	0.633	CNW	
Tpbt4	0.467	0.248	0.555	ptn21				BT4	0.467
Tpy	0.320	0.182	0.608	ptn22	0.320	0.182	0.608	TPY	0.320
Tpbt3	0.424	0.217	0.519	ptn23	0.424	0.217	0.519	BT3	0.424
Tpp	0.499	0.178	0.361	ptn24	0.499	0.178	0.361	TPP	0.499
Tpbt2	0.504	0.185	0.369	ptn25	0.504	0.185	0.369	BT2	0.461
Tptrv3/(rn)	0.464	0.172	0.404	ptn25	0.464	0.172	0.404	BT2	
Tptrv2	0.306	0.148	0.499	tsw31	0.207	0.106	0.593	BT2	
Tptrv1	0.062	0.044	0.730	tsw31				TC	0.062
Tptrn2	0.126	0.080	0.665	tsw32	0.148	0.074	0.520	TR	0.148
Tptrn	0.150	0.074	0.507	tsw32				TR	
Tptrl2	0.164	0.106	0.660	tsw33	0.154	0.108	0.717	TUL	0.155
Tptrl1	0.163	0.110	0.689	tsw33				TUL	
Tptrl	0.171	0.094	0.559	tsw33				TUL	
Tptul2	0.152	0.117	0.778	tsw33				TUL	
Tptul1	0.156	0.115	0.755	tsw33				TUL	
Tptul	0.147	0.097	0.688	tsw33				TUL	
Tptmn3	0.109	0.098	0.902	tsw34	0.110	0.093	0.850	TMN	0.110
Tptmn2	0.139	0.124	0.895	tsw34				TMN	
Tptmn1	0.112	0.099	0.897	tsw34				TMN	
Tptmn	0.107	0.089	0.835	tsw34				TMN	

RF 4/28/00

82

For comparison, I plotted the saturation profiles for boreholes SD-9 and SD-12 using the geophysical data files obtained by Larry McKague for me from the DOE (Howard Rael [SAIC, 702-295-5756] was the contact/keeper of the data for the M&O; the M&O released the data as preliminary, not QA'd yet). The data imported into an Excel 97 SR-2 spreadsheet, then imported into SigmaPlot for plotting. With the geophysical data files, "odsats" and odpors" were plotted (oven day methods as described in Flint, 1998). I also plotted the TDMS saturation data for SD-6. All of these generally agree with the shape of the profiles.

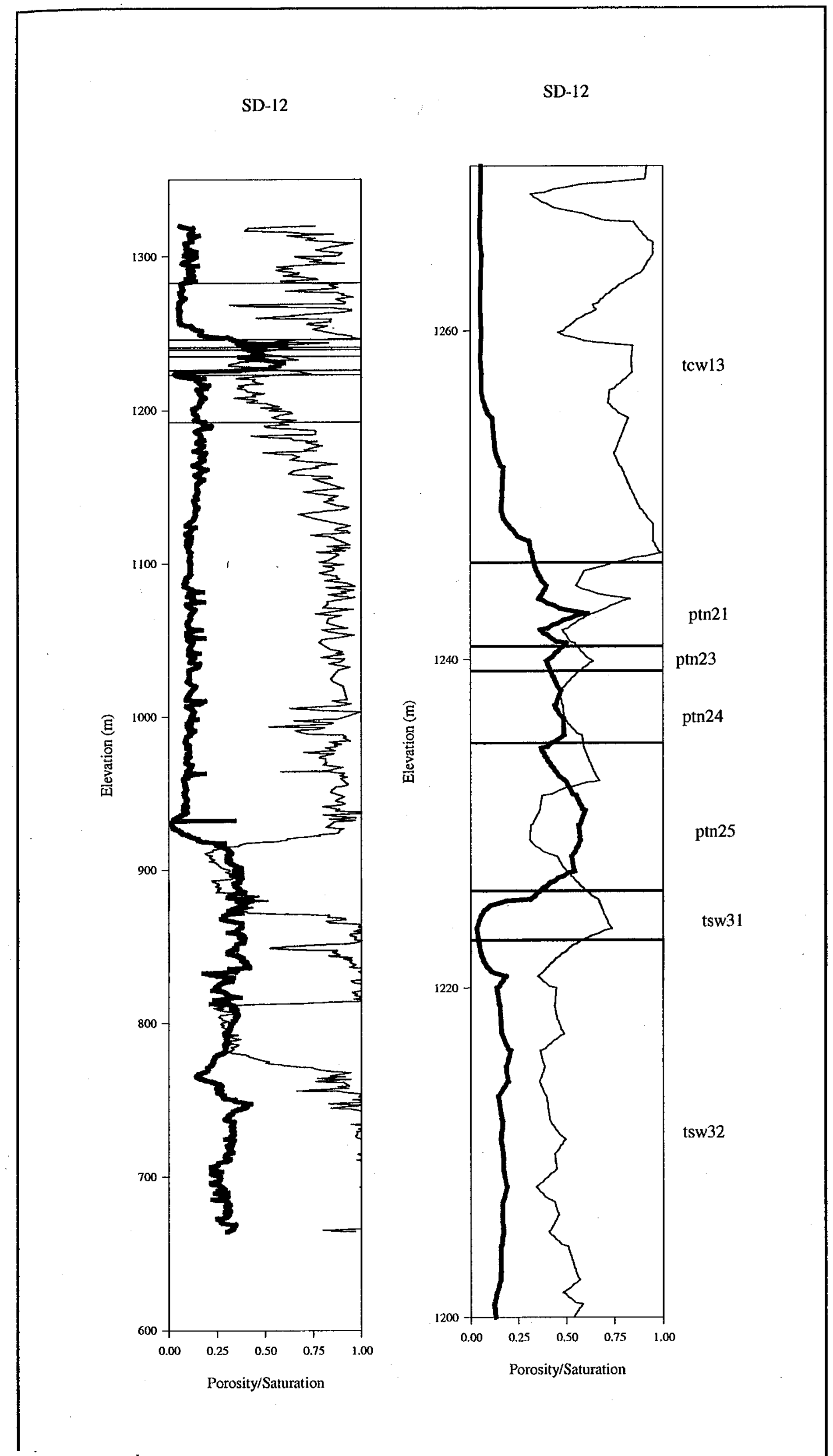
SD-9
J:\HydroProperties\WaterContent\Sd-9\sd9.JNB derived from:
D:\Zeolites\Geophys\Paasd9.txt, D:\Zeolites\Geophys\Excel4.0\sd9.xls, D:\Zeolites\Geophys\SigmaPlt\sd9.JNB



RF 4/28/00

RF 4/28/00

SD-12
J:\HydroProperties\WaterContent\Sd-12\sd12.JNB derived from:
D:\Zeolites\Geophys\Paasd12.txt, D:\Zeolites\Geophys\Excel4.0\sd12.xls

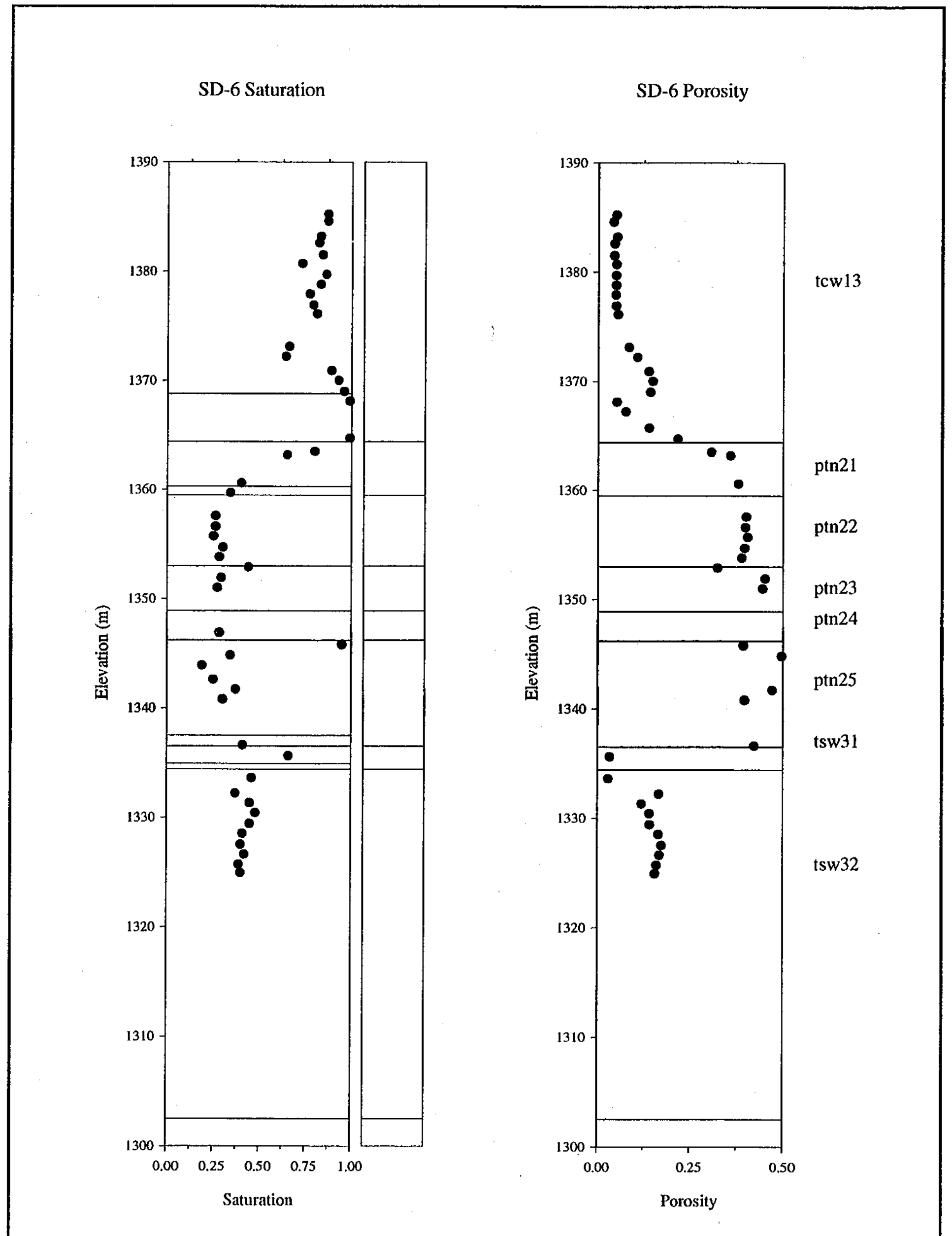


RF 4/28/00

RF 4/28/00

84
SD-6
Data on saturations was obtained from Yucca Mtn Data Web page (TDMS):
[http://m-oext.ymp.gov/html/prod/db_tdp/sep/internet/default.htm]
Info on data retrieved from web site TDMS (technical data management system):
Data for SD-6 downloaded from YMP data web page (3/16/00) [DTN: GS980908312242.039]; dowloaded file name zz_sep_97642.txt

547592 Easting, UTM (m) NAD27?, data from borehole list D. Simms
4077514 Northing, UTM (m)
4905.4 Elevation of collar (ft) from Sci Ntbk #273, p.53
Lithologic Contacts from YMP data web page downloaded 7/99 [DTN: SNF40060298001.001]
Saturations downloaded (file: zz_sep_97630.txt) from YMP data web page 3/17/99 [DTN: GS980808312242.014]
Porosity downloaded (file: zz_sep_97629.txt from YMPdata web page 3/17/99 [DTN: GS980808312242.014]



RF 4/28/00

DOE Coordinates for ECRB

Instead of using the digitized coordinates (see page 74) for the ECRB (east-west cross-drift → enhanced characterization repository block ?), the DOE GIS files were obtained by Deborah Waiting. The e00 machine portable archive file could directly be imported into ArcView 3.1 (instead of going through ArcInfo).

Since the file was originally in State Plane NAD27, Deborah re-projected it to UTM NAD27 (m). They are shape files

They are saved in J:\AVData\Repository\DOE_ecrb*
ecrbsutm.*

These should replace all previous usage in project files; the esf and repository footprint shape files are still good and need not be replaced

Effect of Thermal Pulse on Calico Hills Nonwelded, Nonaltered Matrix Flow 10/2/00

The central and southwest portions of the repository are underlain by nonwelded and nonalterd vitric tuffs according to the DOE model (UZ PMR and GFM/ISM 3.1). Based on Goodluck's thermal pulse modeling and the DOE's thermal modeling on site-scale grids (Thermal Modeling PMR), the temperatures caused by the thermal pulse in the Calico Hills (<100 m) are expected to exceed 75 deg C for an extended period of time. In the central and southwest portions of the repository footprint, the CHn is not altered to zeolites. In the western portion of repository, the CHn is easily within 100 m of the repository. R. Pabalan (CNWRA) believes that 75 deg C for decades to centuries is a high enough temperature to get the kinetics moving along for the alteration of the nonwelded, vitric matrix to zeolites.

Two important ideas come to bear here: (i) matrix flow through the nonwelded matrix is the primary natural barrier for transport in the UZ, and (ii) the LBNL UZ site-scale flow model uses ambient hydrologic properties instead of properties that are expected to be relevant for the 10,000 year compliance period (the thermal pulse is expected to be at full extent ~1000 to 2000 years after closure). Alteration of the nonwelded matrix means that more lateral flow and fracture flow will occur. This alteration is expected to lead to more perching and lateral flow to fault or large fractures.

My two initial objective are (i) to obtain nonwelded vitric samples for lab work with Pabalan (permeability as a function of extent of alteration; also do some retention curves), and (ii) check GFM 3.1 to determine actual distances between the repository and the nonwelded vitric layers.

The locations of the points are shown in the figure to the right and are noted in the printout of the spreadsheet on the next scientific notebook page: (file: thicknessSWrepsoitory.xls).

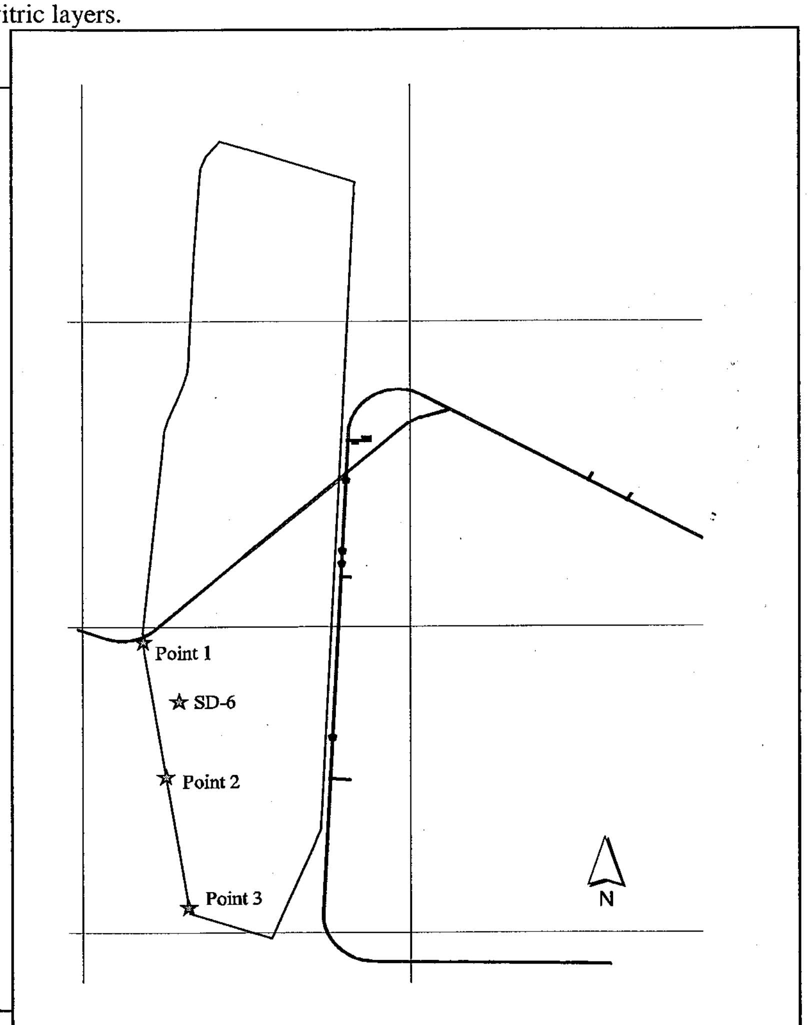
SD-6 information is from page 84 of this scientific notebook. The contacts are specifically from DTN: SNF40060298001.001

The figure was created using the ArcView 3.2 project file:

J:\AVData\Repository\thicknessSW.apr

The gird lines on the figure are spaced at 2,000 m increments (UTM NAD27 northing lines at 4,080,000 and 4,078,000 and 4,076,000 meters; and easting lines at 547,000 and 549,000 m).

Points 2 & 3 were chosen because the DOE EDA-II design data also included elevations.



Distances between Repository and Nonwelded, Nonaltered Vitric Horizons [RFedors Sci Ntbk #273]
This file is bubo: J:\HydroProperties\ThermalZeol\thickness-SWrepository.xls
Tops of Units are from EarthVision GFM3.1 model, faces file pluto:
/data2/models/gfm31/M09901MWDGFM31.000/GFM3_1_HiRes.unsliced.faces
Results stored in pluto: ~rfedors/ThermalZeol/* ; data from the annotation files is recorded below
SD-6 data from J:\HydroProperties\WaterContent\Sd-6\contactElevSD6.txt

	Thermal-Mech. Units	LBNL UZ Model Units	Point 1 elev, ft	Point 2 elev, ft	Point 3 elev, ft	Point 1 elev, m	Point 2 elev, m	Point 3 elev, m	SD-6 elev, m	SD-6 lith
46	Tiva_Rainier	tcw11		4921.551758	4789.72559		1500.1	1459.9		
45	Tpcp	tcw12		4860.35791	4769.21533		1481.4	1453.7	1495.2	Tpc_un
44	TpcLD			4533.437012			1381.8			
43	Tpcpv3	tcw13		4532.014648	4452.68945		1381.4	1357.2	1368.8	Tpcpv3
42	Tpcpv2			4517.455566	4435.80811		1376.9	1352.0	1368.8	Tpcpv2
41	Tpcpv1	ptn21		4505.432129	4423.76856		1373.3	1348.4	1364.4	Tpcpv1
40	Tpbt4			4493.292969	4410.05469		1369.6	1344.2	1360.3	Tpbt4
39	Yucca	ptn22		4488.726562			1368.2		1359.5	Tpy
38	Tpbt3_dc	ptn23		4483.699219	4406.74512		1366.6	1343.2	1353	Tpbt3
37	Pah	ptn24		4471.486816	4393.0708		1362.9	1339.0	1348.9	Tpp
36	Tpbt2	ptn25		4465.874023	4388.75879		1361.2	1337.7	1346.2	Tpbt2
35	Tptrv3		4464.53613	4441.604492	4364.79248	1360.8	1353.8	1330.4	1337.5	Tptrv3
34	Tptrv2	tsw31	4461.69971	4437.177734	4361.13965	1359.9	1352.5	1329.3	1336.5	Tptrv2
33	Tptrv1		4458.31885	4431.898438	4356.96338	1358.9	1350.8	1328.0	1334.9	Tptrv1
32	Tptrn	tsw32	4456.79199	4430.728027	4356.08594	1358.4	1350.5	1327.7	1334.4	Tptrn
31	Tptrl	tsw33	4350.86768	4340.775879	4272.55811	1326.1	1323.1	1302.3	1302.5	Tptrl
30	Tptpul		4330.36816	4310.879395	4259.51367	1319.9	1314.0	1298.3	1298.4	Tptpul
29	RHH(Tpcpul)		4179.23242	4214.32666	4181.26758	1273.8	1284.5	1274.5		
28	Tptpmn	tsw34	4110.41602	4130.495605	4103.07178	1252.9	1259.0	1250.6	1235.2	Tptpmn
27	Tptpll	tsw35	3980.20508	3990.30127	3953.05298	1213.2	1216.2	1204.9	1191.9	Tptpll
26	Tptpln	tsw36	3665.77319	3704.254883	3729.8584	1117.3	1129.1	1136.9	1097.4	Tptpln(2/3)
		tsw37	3573.31554	3606.655599	3633.54363	1089.1	1099.3	1107.5	1066.7	Tptpln(1/3)
25	Tptpv3	tsw38	3527.0874	3557.856689	3585.38696	1075.1	1084.4	1092.8	1051.4	Tptpv3
24	Tptpv2	tsw39	3466.70361	3513.986084	3491.14136	1056.7	1071.1	1064.1	1037.1	Tptpv2
23	Tptpv1	ch1	3451.52466	3479.635986	3455.43066	1052.0	1060.6	1053.2	1031.9	Tptpv1
22	Tpbt1		3425.07275	3447.134277	3408.42505	1044.0	1050.7	1038.9	1022.1	Tpbt1
21	Calico	ch2,3,4,5	3418.44141	3437.128174	3398.62305	1041.9	1047.6	1035.9	1019.4	Tac
20	Calicobt	ch6	3310.11182	3343.049805	3338.2666	1008.9	1019.0	1017.5	988	Tacbt
19	Prowuv	pp4	3256.52319	3296.468262	3286.74219	992.6	1004.8	1001.8	972.4	Tcpuv
18	Prowuc	pp3	3229.43311	3273.762451	3263.43115	984.3	997.8	994.7	964.8	Tcpuc
17	Prowmd	pp2	3108.04321	3140.036133	3136.74097	947.3	957.1	956.1	924.6	Tcpm
16	Prowlc		3090.82593	3099.95752	3083.6543	942.1	944.9	939.9	920.6	Tcplc
15	Prowlv	pp1	3070.62012	3073.243164	3062.32031	935.9	936.7	933.4	913.6	Tcplv
14	Prowbt		2932.32324	2895.21875	2856.81348	893.8	882.5	870.8	860.9	Tcpbt
13	Bullfroguv		2908.98926	2876.608398	2845.25293	886.7	876.8	867.2	854.2	Tcbuv
12	Bullfroguc	bf3	2878.77783	2855.862793	2832.53857	877.5	870.5	863.4	848.3	Tcbuc
11	Bullfrogmd		2803.46411	2791.794189	2741.55469	854.5	850.9	835.6	819.4	Tcbm
10	Bullfroglc		2595.1604	2530.564453	2483.32178	791.0	771.3	756.9	740.2	Tcblc
9	Bullfroglv	bf2	2538.30786	2479.047607	2435.39697	773.7	755.6	742.3	731.3	Tcblv
8	Bullfrogbt		2384.08545	2377.424561	2363.31665	726.7	724.6	720.3		Tcbbt
7	Tramuv		2359.19043	2356.045654	2338.53882	719.1	718.1	712.8		Tctuv
6	Tramuc	tr3	2261.24292	2267.040527	2263.02612	689.2	691.0	689.8		Tctuc
5	Trammd		2188.62695	2177.313232	2153.27979	667.1	663.6	656.3		Tctm
4	Tramlc		1920.82898	1843.411133	1768.87097	585.5	561.9	539.2		Tctlc
3	Tramlv	tr2	1901.38281	1817.962524	1736.87354	579.5	554.1	529.4		Tctlv
2	Trambt		1619.57654	1441.4646	1283.53394	493.6	439.4	391.2		Tctbt
1	Tund		1607.08875	1416.29834	1245.42773	489.8	431.7	379.6		Tund

RF 3/14/01

RF 3/14/01

The data for the contacts listed in the table on the previous page come from GFM3.1 using a .path file to extract a cross-section from the faces file supplied by DOE. The faces file is:
/data2/models/gfm31/M09901MWDGFM31.000/GFM3_1_HiRes.unsliced.faces
After creating the path files with the ~0.5 m cross-section traverse, the menu options used to create the annotation file are : Visualization → Cross-Sections → from Faces File. The top of each lithologic layer are read from the polygon information used to draw a cross-section in the annotation file.

Interpolations of elevations of the repository used EDA-II design (see page 61) were needed for Point 1 and for the SD-6 borehole. The elevations used to interpolate from are noted on page 61 of this sci ntbk. Note that there is no inclination east-west but there is a slope downward to the north. The control point to the north is the northing 769319.9 ft and the elevation of 1065; the control point to the south Point 2. Point 1 is 0.6645 (fraction) of the distance between the 2 control points and SD-6 is 0.8127 of the distance. Hence, their elevations are the fraction times the difference in elevations (36.18 ft) added to the lower elevation. Since the EDA-II design used State Plane NAD27 (ft) coordinates, all coordinates had to be converted prior to doing the interpolation.

	UTM NAD27		State Plane NAD27 (ft)	
	Easting, m	Northing, m	Easting, m	Northing, m
Point 1	547370.9	4077904	557931.5	763573.3
Point 2	547510.7	4077020	558380.1	760671.4
Point 3	547648.7	4076168	558823.3	757872.9
SD-6	547592	4077514	558652.6	762290.9

The distance between the repository and the nonwelded/nonaltered horizons is calculated two ways. The distance down to the contact tsw39/ch1 is the best one to use. The distance down to the massive CHn (ch1/ch2 contact) is also calculated. The lowest sublayers of the Topopah Springs are a gradation of 3 units from densely welded to completely nonwelded; hence the actual thicknesses are kind of arbitrary. Then there is a bedded tuff at the base of the Topopah Springs. Whereas the contact with the massive CHn (ch1/ch2) is abrupt, the contact between the tsw39 and ch1 is gradational. The lowermost Topopah Springs nonwelded tuff sublayer, and the bedded tuff below it, both readily alter to zeolites (propbably more readily than the massive layers), thus the argument for using the massive Calico Hills at which to estimate temperatures in the site-scale thermal model for use in the determination of potential zeolization during the thermal pulse.

	UTM NAD27		Repository	Top (m)	Top (m)	Distance to nonwelded	Distance to massive Calico
	Easting, m	Northing, m	Elev, m	Tpbt1, in ch1	Calico (ch2)	(top ch1), m	(ch2), m
Point 1	547370.9	4077904	1089	1044.0	1041.9	37.0	47.1
Point 2	547510.7	4077020	1102.2	1050.7	1047.6	41.6	54.6
Point 3	547648.7	4076168	1110.5	1038.9	1035.9	57.3	74.6
SD-6	547592	4077514	1094.4	1022.1	1019.4	62.5	75.0

I checked points along the western edge of the repository, southern half only (the nonwelded vitric layers are thought to be more altered in the north than the south, but this is not true for the upper horizons of the Calico Hills). I also checked borehole SD-6; this is a control point since the other locations are interpolations. The distance between the nonwelded, nonaltered vitric horizons and the repository varies from 47 m to 75 m with the variation corresponding to the east-southeast trend of the repository outline in that area. Note that this is much less than the 100 m I roughly approximated when I was checking the temperature distributions in Goodluck's and the DOE's thermal models.

Point 2 is recommended for use in creating a grid. Although Point 1 has the smallest distance between the repository and the CHnv, one may want to avoid using it becasue it does not have any overlying PTn. There is only a small portion of the repository without overlying PTn, hence Point 1 is not representative.

RF 3/14/01

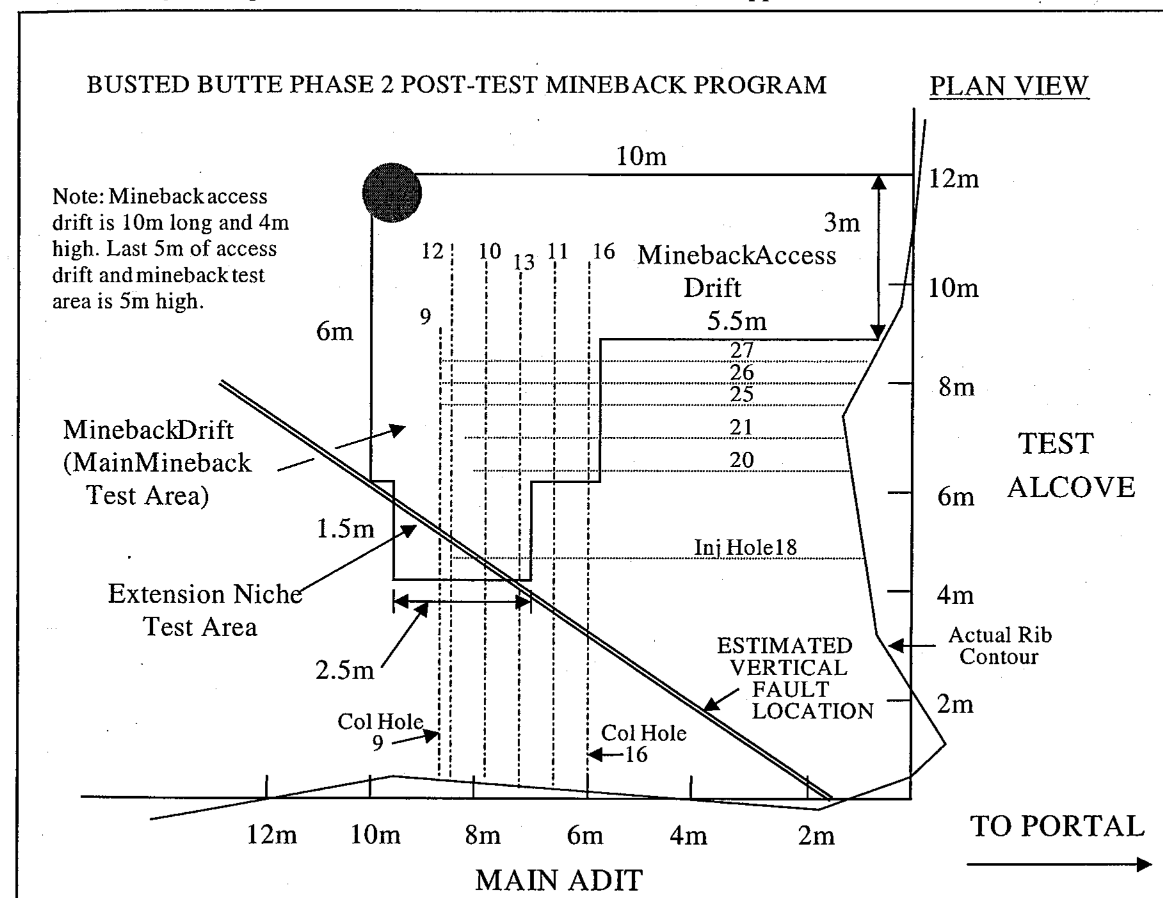
RF 3/14/01

Busted Butte Samples

3/14/01

The question of the effect of the thermal pulse on the hydraulic properties of the CHnv layer below the repository arises for the heat load of the Viability Assessment design; the CHnv is as close as 40m below the repository in the south and central western portions and could readily alter to zeolites at temperatures down to 75 degrees C according to Bobbie Pabalan. The temperatures expected for the VA heat load were modeled as 100 degrees C down to the CHn. If alteration did occur, the remainder of the matrix flow below the repository would shift to fracture flow, thus increasing the magnitude of the early fracture flow component of radionuclide transport.

Last fall when I heard that the Phase II injection test block was going to be mined back (half meter by half meter faces), I requested that samples of the 3 horizons in the Busted Butte test sequence. The massive lower layer of the test is considered by DOE to be an analog of the CHnv below the repository. After some email and telephone discussions (Tom Ricketts, Alan Mitchell) about the logistics and many delays in the onset of the mineback, I am loosely scheduled to visit the site during early May when there is a lull in the mineback (during the time of LANL scientific work on the newly exposed faces). I will use seran wrap to keep the samples from drying out and to keep them intact (the lower layer becomes extremely friable when dry). The YMP crew will use a chain saw-type tool to cut out 6 inch to 8 inch chunks for us at the locations we mark. The location will be from the area marked by the solid circle in the figure below. This is in approximately the northeast corner of the mineback and should be the least contaminated by the injection lexir of the LANL tests. Nine different chunks were requested from the 3 different layers (lower Topopah Springs, ash layer, and massive CHnv). The figure below came from Tom Ricketts and is stored as J:\HydroProperties\ThermalZeol\BB_P2Mnbck_PlnVw_2.ppt on the WinNT machine called bubo.



RF 8/30/04 Samples obtained from mine-back on 5/22/01. Field visit & sample locations from Busted Butte are recorded in field scientific notebook #428, page 33-46.

Last entry RF 8/31/04

I have reviewed this SN and have determined that it complies with QAP-001. A suitably trained hydrogeologist should, on the basis of the information contained herein, be able to replicate this work.

Gordon Wittmeyer 9/21/2004

ADDITIONAL INFORMATION FOR SCIENTIFIC NOTEBOOK NO. 273

Document Date:	06/04/1998
Availability:	Southwest Research Institute® Center for Nuclear Waste Regulatory Analyses 6220 Culebra Road San Antonio, Texas 78228
Contact:	Southwest Research Institute® Center for Nuclear Waste Regulatory Analyses 6220 Culebra Road San Antonio, TX 78228-5166 Attn.: Director of Administration 210.522.5054
Data Sensitivity:	■"Non-Sensitive" ☐ Sensitive ☐"Non-Sensitive - Copyright" ☐ Sensitive - Copyright
Date Generated:	08/31/2004
Operating System: (including version number)	Windows NT/UNIX
Application Used: (including version number)	Tecplot 7.0, EarthVision 5.0, ArcView 3.2a, Excel 97, WordPerfect 8.0, Illustrator 8.0, Sigma Plot 5.0
Media Type: (CDs, 3 1/2, 5 1/4 disks, etc.)	2 - CD
File Types: (.exe, .bat, .zip, etc.)	various
Remarks: (computer runs, etc.)	Media contains: data files for computational work in unsaturated flow modeling